# Marine Fisheries REVIEW

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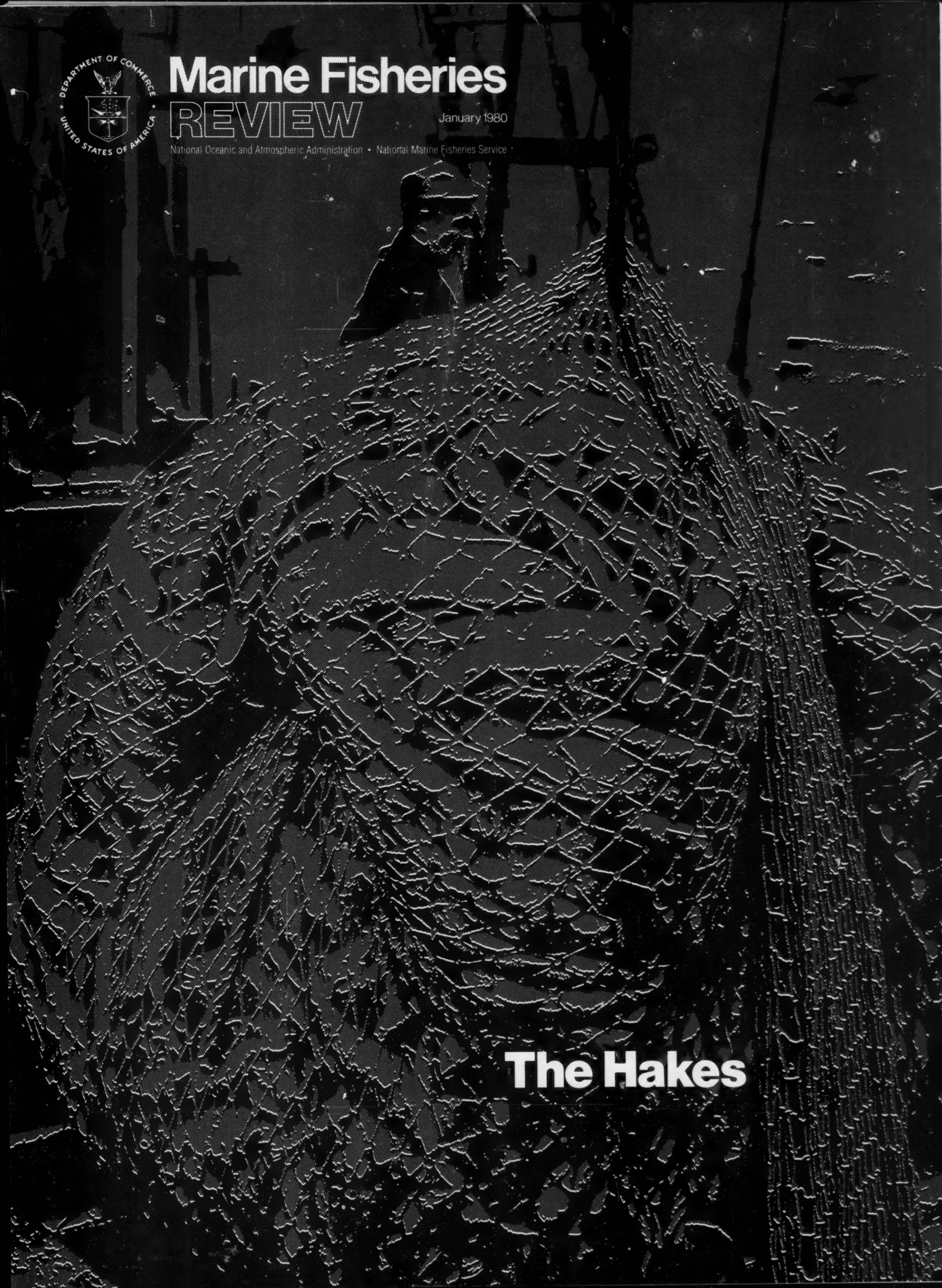

# The Hakes

# Marine Fisheries REVIEW


On the cover:
A catch of hake.

Articles

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# Industry Outlook for Greater Utilization of Hake Products

LEE J. WEDDIG

All indications point to greater utilization of hake products in the U.S. market, provided quality requirements at competitive prices are met.

The continued growth of fish stick and portion production as well as the growth in use of fillets of all types, especially groundfish, provides a solid base for hake.

### Fish Sticks and Portions

In 1978, production of fish sticks and portions reached 480 million pounds, with the major growth occurring in fish portions. Portion production used for both the food service and retail market places has grown from 217 million pounds to 386 million pounds in the 1969-78 period. Gains were registered in each year except 1974. Fish stick production has fallen since reaching a peak in 1973, even though 1978 showed a healthy jump from 1977.

Fish blocks used to manufacture these portions and sticks are 99.5 percent imported. In 1978, record supplies of 406 million pounds were brought into the country with a declared value of $325 million. Block usage rose from 378 million pounds to 406 million pounds last year.

The increase last year (1978) was entirely in the whiting and "other" category with Argentina showing up as a major supplier of whiting products. Other new sources are also being developed. Total whiting block imports were almost 40 million pounds.

The acceptance of whiting as an ingredient in the stick and portion business is a good indicator for those interested in developing the hake resources. Major manufacturers of sticks and portions maintain rigid quality standards which would have to be met to enable a trial of domestic hake blocks.

### Fillets

The use of groundfish fillets has paralleled stick and portion growth. In 1978, record consumption of 295 million pounds was achieved, up from 277 million the year before. While imports constituted 79 percent, it is significant to note that the percentage of imports to the total supply is down from several years ago. United States domestic groundfish fillet production has been moving upwards steadily since 1975.

The steady expansion of the groundfish fillet market offers ready opportunity for white-fleshed fillets of all types such as can be produced under proper conditions from hake. The market is expanding for both fresh and frozen forms.

### Other Product Forms

While existing product forms are the most logical target for hake products in the United States, the industry should anticipate and work toward innovative alternates. Such items as seafood patties and stuffing presently use white-fleshed fish as ingredients. Hake could be an attractively priced alternate.

A most promising application could be combination meat-fish products such as sausages and patties. Presently, Department of Agriculture regulations are barriers to such development. A combined industry effort could ease these restrictions, opening the door to an exciting potential.

In addition to the opportunities for domestic use of hake, one has to assume potential for export, given the concentration of foreign fishing on the resource.

Overall, it would appear that a definite market potential exists, a potential that can be met by the U.S. industry.

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# Names of the Hakes

DANIEL M. COHEN

Most kinds of fishes do not have a legal or official common name, and common names in use for any particular species may vary from one region to another, from one group of users to another, and even with size, season, or sex. Thus a biological species may have one or more common names, and equally, or even more troublesome, two or more species may have the same common name. The nature of common names and their relationship to Latinized scientific names has been discussed at greater length by Cohen (1974).

The origins of the word hake are not at all clear. According to the Oxford English Dictionary the first usage was in the 14th or 15th century, and the word as presently understood refers in general to the genus *Merluccius* and several other genera of gadoid (cod-like) fishes.

Fish species classified in the genus *Merluccius* as well as several other genera are often considered to be members of a family Merluciidae, which although related to is distinct from the Gadidae or cod family proper (Marshall and Cohen, 1973). The various named species of *Merluccius* are rather similar in appearance, and there is not at this time any good way to assign the correct scientific name to *Merluccius* from many regions of the world. There may be as few as 4 or as many as 15 or more different biological species. The taxonomy of *Merluccius* is being studied at present by a Japanese ichthyologist, Tadashi Inada. Whatever may be the number and correct scientific names of *Merluccius* species, all are known in English speaking countries as hake.

Other English language names also are used for *Merluccius*, the chief being whiting. In a study of the taxonomy of North and South American *Merluccius* (Ginsberg, 1954), whiting was used as a general name for all species of the genus. *Merluccius bilinearis* (Fig. 1) from the western North Atlantic is called whiting as well as silver hake (Bigelow and Schroeder, 1953), and in New Zealand *M. australis* is known as whiting or hake (Graham, 1956). The U.S. Food and Drug Administration has approved the designation as whiting of five nominal species of *Merluccius: bilinearis* from the east coast of North America; *productus* from the west coast of North America, *capensis* from South Africa; *gayi* from Chile; and *hubbsi* from Argentina. In South Africa, stockfish is another name for *Merluccius* (Smith, 1954).

Hake is used as a common name for a number of kinds of fishes other than *Merluccius*. Among the Gadidae are six species of *Urophycis* from the western Atlantic (Bigelow and Schroeder, 1953; Bailey et al., 1970): *chuss*, red or squirrel hake; *cirratus*, Gulf hake; *earlii*, Carolina hake; *floridanus*, southern hake; *regius*, spotted hake (Fig. 2); *tenuis*, white, black, mud, or Boston hake. Several other species of *Urophycis* live along the east coast of South America but do not have English language common names. The related gadid genus *Phycis* has one western Atlantic species, *P. chesteri* (Fig. 3), called the longfinned hake (Bigelow and Schroeder, 1953; Bailey et al., 1970), and two eastern Atlantic species known as forkbeards. Two members of the gadoid family Moridae must be listed, the nearly cosmopolitan deepsea *Antimora rostrata* (Fig. 4), known as blue hake (Bigelow and Schroeder, 1953), and

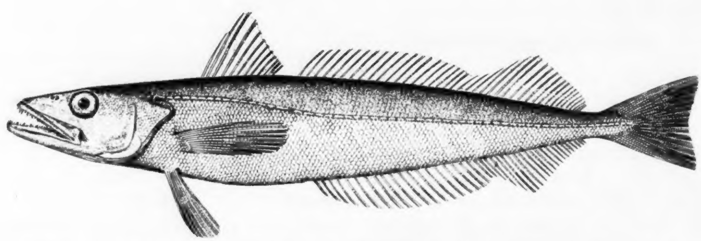

Figure 1.—*Merluccius bilinearis* from the western North Atlantic, where it is called hake or whiting.

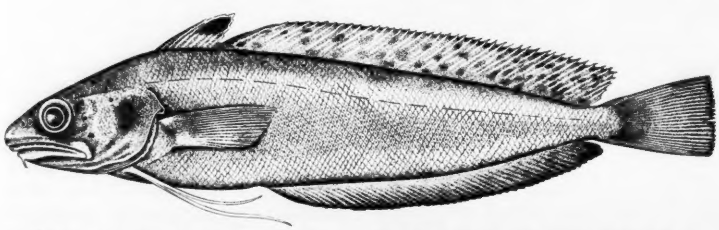

Figure 2.—*Urophycis regius*, a common fish of the U.S. east coast, where it is known as spotted hake.

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the New Zealand *Lotella rhacina,* called southern hake or rock cod (Graham, 1956). Finally, *Rexea solandri* (Fig. 5), a member of the Gempylidae or snake mackerel family, and not all related to the cods, has hake as an alternative name in both New Zealand (Graham, 1956; Whitley, 1968) and Australia (Munro, 1958).

As noted above the name whiting is used interchangeably with hake for *Mercuccius;* however, it is used also for fishes that are not called hakes. Among them are three species of European Gadidae (Wheeler, 1969): *Merlangius merlangus,* whiting; *Trisopterus luscus,* whiting pout, an alternate name for bib; and *Micromesistius poutassou,* blue whiting (caught rarely off the U.S. east coast where it has no common name). Whiting is also an alternate name for the eastern North Pacific gadid *Theragra chalcogramma,* often called walleye pollock (Hart, 1973; Bailey et al., 1970). Members of the genus *Menticirrhus* of the croaker family Sciaenidae, not at all closely related to gadoids and with three Atlantic and one Pacific U.S. species, are known collectively as whitings, although each also has other common names (Hildebrand and Schroeder, 1928; Bailey et al., 1970). Species belonging to several other families of fishes unrelated to gadids are known as whitings (Scott, 1962); among them are the spiny-rayed Sillaginidae of the Indian Ocean and western Pacific, and the Odaciidae, called rock whitings, wrasse-like fishes of Australia and New Zealand. Finally sand whiting is listed as an alternate for the bothid flatfish *Scopthalmus aquosus,* most commonly known as windowpane (Bailey et al., 1970).

Obviously, the nomenclature of hakes and whitings is complex. Positive identification of a species referred to under these names may require reference to a Latinized scientific name; although, even some of these are subject to question.

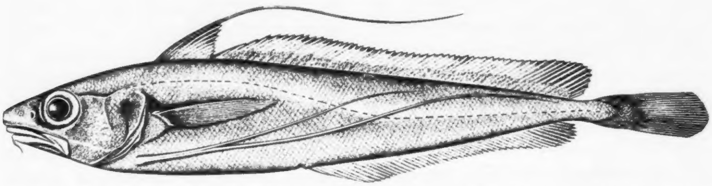

Figure 3.—*Phycis chesteri,* the longfinned hake, found on the continental slopes of eastern North America.

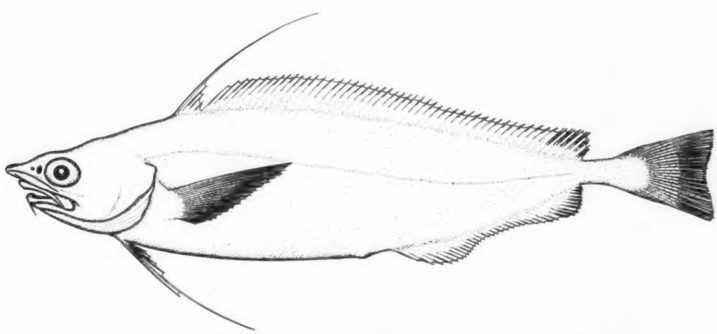

Figure 4.—*Antimora rostrata,* a deepsea fish living in many of the world's seas, is known as the blue hake.

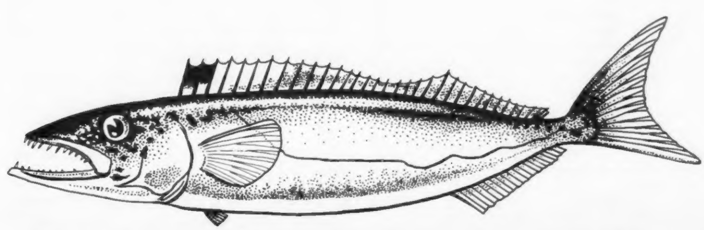

Figure 5.—*Rexea solandri* from New Zealand and Australia, where it is called hake or king barracouta.

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# World Utilization of Hake

DONALD R. WHITAKER

## Introduction

In the last 10-15 years hake has become an increasingly important world fishery. In the 1960's, hake was used to a large extent for fish meal production, especially in South America. At the same time there began to be a very active interest in certain Atlantic hake stocks for human consumption. During the last few years there has been growing pressure on cod supplies. Hake has emerged as one of the more promising substitues for white-fleshed fish such as cod, haddock, flounders, soles, etc. (Schroeder et al., 1978).

The purposes of this paper are fourfold: Review trends in world catches, indicate the products produced, look at world trade, and briefly review the major market areas for hake products.

## World Catch

World production of hake increased at a rate of nearly 8 percent per year during 1971-76. The catch in the 36 major producing countries rose from 1.5 million tons in 1971 to 2.1 million tons in 1976 (Table 1). The Soviet Union is by far the largest producer of hake, accounting for 32-55 percent of the world catch. The Russian catch has declined by about 30 percent in recent years. Its catch may decline even further with the advent of extended fishery jurisdictions around the world.

The second largest producer and market is Spain. Its catch has risen by the use of long-distance freezer trawlers but, like the U.S.S.R., Spain's catch of hake may decline somewhat in the future.

African production is dominated by South Africa which regularly accounts for about 90 percent of that area's production. Production has been stable in recent years.

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**Table 1.—Hake production by countries (1,000 tons, live weight).**

| Country | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|
| Africa | | | | | | |
| Angola | — | 0.1 | 0.1 | 0.1 | 0.1 | — |
| Cameroon | — | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Egypt | 0.2 | 0.1 | 0.1 | — | — | — |
| Ghana | — | 1.3 | 4.9 | 11.6 | 1.4 | 0.3 |
| Morocco | 2.9 | 2.6 | 2.9 | 5.1 | 4.4 | 0.1 |
| South Africa | 111.5 | 118.1 | 133.0 | 134.9 | 113.1 | 118.2 |
| Tunisia | 0.4 | 0.2 | 0.6 | 0.8 | 0.8 | 0.8 |
| Zaire | 2.8 | 2.8 | 5.8 | 5.8 | 5.8 | 2.7 |
| Subtotal | 117.8 | 127.7 | 149.9 | 160.8 | 128.1 | 124.6 |
| N., S. America | | | | | | |
| Cuba | 39.8 | 49.0 | 31.3 | 31.7 | 31.7 | 57.5 |
| U.S.A. | 20.0 | 13.8 | 20.5 | 14.8 | 22.5 | 42.1 |
| Argentina | 92.0 | 102.8 | 151.4 | 162.2 | 109.0 | 174.9 |
| Brazil | 18.2 | 14.0 | 31.6 | 33.6 | 33.6 | 33.1 |
| Chile | 66.0 | 66.9 | 46.5 | 43.1 | 43.1 | 29.5 |
| Peru | 26.2 | 12.6 | 132.1 | 109.4 | 84.9 | 92.8 |
| Uruguay | 3.7 | 8.5 | 4.5 | 1.5 | 9.8 | 11.7 |
| Subtotal | 265.9 | 267.6 | 417.9 | 396.3 | 334.6 | 441.6 |
| Asia | | | | | | |
| Israel | 8.6 | 9.2 | 6.5 | 5.7 | 6.0 | 6.3 |
| Japan | 64.8 | 56.1 | 70.1 | 63.3 | 54.4 | 66.4 |
| Subtotal | 73.4 | 65.3 | 76.6 | 69.0 | 60.4 | 72.7 |
| Europe | | | | | | |
| Belgium | 0.2 | 0.2 | 0.2 | 0.4 | 0.7 | 3.5 |
| Bulgaria | 22.4 | 22.9 | 19.3 | 13.8 | 13.4 | 54.5 |
| Denmark | 1.2 | 1.4 | 1.4 | 1.8 | 2.3 | 140.5 |
| France | 24.0 | 22.3 | 24.7 | 23.0 | 24.2 | 65.6 |
| German Dem. Rep. | 8.1 | 0.2 | 5.0 | 1.3 | 10.6 | 31.0 |
| Fed. Rep. Germany | 6.1 | 4.1 | 1.5 | 0.2 | 3.7 | 12.2 |
| Ireland | — | 0.1 | 0.1 | 0.1 | 0.3 | 10.7 |
| Italy | 10.7 | 12.9 | 11.5 | 13.6 | 14.3 | 28.0 |
| Netherlands | 0.2 | 0.1 | 0.3 | 0.2 | 0.1 | 12.9 |
| Norway | 0.8 | 0.7 | 1.0 | 0.7 | 0.4 | 0.8 |
| Poland | 0.2 | 3.4 | 39.2 | 76.9 | 94.8 | 84.8 |
| Portugal | 31.8 | 27.2 | 44.0 | 28.6 | 19.4 | 35.4 |
| Spain | 229.2 | 259.2 | 263.4 | 218.5 | 254.1 | 263.4 |
| Sweden | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 1.8 |
| United Kingdom | 2.8 | 2.9 | 2.8 | 2.6 | 2.8 | 57.4 |
| Yugoslavia | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 |
| Rumania | 1.7 | 0.3 | 0.2 | 0.5 | 0.3 | 1.8 |
| Subtotal | 340.0 | 358.5 | 415.4 | 383.1 | 442.4 | 805.0 |
| U.S.S.R. | 736.2 | 1,035.2 | 1,072.9 | 746.9 | 640.7 | 680.8 |
| Grand Total | 1,533.3 | 1,854.3 | 2,132.7 | 1,756.1 | 1,606.2 | 2,124.7 |

Source: FAO Fishery Statistics Yearbook, various volumes.

The area where production is growing the fastest is North and South America. Here production increased by 13 percent per year during 1971-76. Argentina and Peru account for nearly two-thirds of the catch in the Americas at present.

### Potential Catches

World attention has turned to the potential for increasing hake production in Latin America. Table 2 indicates that this area has the potential for doubling present catches. About half of the relatively untapped potential is found on the Patagonian Shelf off Argentina and Uruguay. The remaining potential is in the eastern Pacific Ocean from the State of Washington to Chile.

Europe and North America are experiencing increasing difficulty in obtaining supplies of traditional white-fleshed species at prices the consumer is prepared to pay. This growing difficulty is shown in Table 3. Catches of the most popular white-fleshed species for the North American and European markets have declined in the 1970's. The catch of Atlantic cod, haddock, and various flatfish peaked at 5.6 million tons in 1969. Since then the combined catches have dropped nearly 30 percent or 1.5 million tons. The last column in the table shows the shortfall in catches of recent years compared with the 1969 peak. The 1.5 to 2.0 million tons of hake being produced annually are helping to supply the demand by this shortfall in catches of traditional species.

### Hake Products

A listing of hake products produced in Uruguay indicates a wide variety of processes and styles are available in the world markets (Mattos and Torrejon, 1978): Heated and gutted; headed and gutted, without tail or fins, scaled, and dressed; individual quick frozen (IQF) fillets; IQF fillets with and without skin, boned; layer pack interleaved fillets; shatter pack interleaved fillets; frozen blocks.

The most important single market for hake products is for fillet blocks in the United States and is based on the consumption of fish sticks and portions. Other markets for hake blocks are to be found in Europe and Australia, while the markets for dressed hake in the United States and Europe are limited, compared with those of fish blocks and frozen fillets, they are expanding (Anderson et al., 1974).

Whole hake can generally be sold only in local markets where the fish are landed. These markets are usually considered as a temporary outlet until a more profitable export trade is developed.

Production of salted hake is limited at present, however there is a large world market for salted products. There has been a recent increase in the production of dried-salted hake—a product that resembles salted-dried cod but costs less. There are great prospects for salted products in Latin America. This is because of the economics, minimal investment and ease of processing, extended keeping qualities, and freedom from complicated chains of distribution (Lupin, 1978).

Peru is a good example of the evolution of hake products being produced in South America. The average percentage of hake utilization in Peru from 1967 to 1970 was originally 90 percent for fish meal (Sánchez and Lam, 1978). In 1976, about 90 percent of the hake catch in Peru was used to process products for human consumption (Table 4).

Hake is generally not used in canned products. However, different whitefish preparations, including hake, could be canned such as fish patties, fish balls, etc. Hake can also be prepared as paste, sausages, etc.

A preliminary investigation showed that all species, except one, examined from South American waters had good gel-forming capacity and thus suitable for kamaboko. Kamaboko and fish sausage make up 26 percent of Japanese fish consumption (Okada, 1978).

The official statistics published by the Food and Agriculture Organization of the United Nations (FAO) show few types of products being produced in

**Table 2.—Estimated hake potentials in North and South America.**

| Country | Potential (tons) |
|---|---|
| Chile | 100,000 |
| Peru | 200-250,000 |
| Argentina-Uruguay | 750,000 |
| Mexico | 300-400,000 |
| U.S.A. (Washington-Oregon) | 90-150,000 |
| Total | 1,440-1,650,000 |

Sources: FAO Fisheries Report 203, (Supplement 1) and National Marine Fisheries Service.

**Table 3.—World production of Atlantic cod, haddock, and selected flatfish (1,000 tons, live weight).**

| Year | Atlantic cod | Haddock | Flounders, plaice, soles, etc. | Total | Shortfall |
|---|---|---|---|---|---|
| 1965 | 2,726 | 748 | 724 | 4,198 | |
| 1966 | 2,874 | 729 | 952 | 4,555 | |
| 1967 | 3,123 | 484 | 1,028 | 4,635 | |
| 1968 | 3,867 | 487 | 969 | 5,323 | |
| 1969 | 3,577 | 902 | 1,077 | 5,556 | |
| 1970 | 3,076 | 913 | 1,044 | 5,033 | 523 |
| 1971 | 2,851 | 506 | 1,154 | 4,511 | 1,045 |
| 1972 | 2,738 | 547 | 1,031 | 4,316 | 1,240 |
| 1973 | 2,541 | 625 | 1,176 | 4,342 | 1,214 |
| 1974 | 2,872 | 582 | 1,128 | 4,582 | 974 |
| 1975 | 2,430 | 529 | 1,091 | 4,050 | 1,506 |
| 1976 | 2,385 | 520 | 1,074 | 3,979 | 1,577 |

Source: FAO Fishery Statistics Yearbook, various volumes.

**Table 4.—Peruvian hake utilization (tons).**

| Year | Fresh | Frozen | Salted/Dried | Sausage | Canned | Fish meal |
|---|---|---|---|---|---|---|
| 1972 | 3,477 | 876 | 743 | — | — | 7,485 |
| 1973 | 4,086 | 41,439 | 297 | 891 | 157 | 85,987 |
| 1974 | 3,016 | 70,068 | 1,509 | 895 | 2,434 | 31,395 |
| 1975 | 4,092 | 66,673 | 1,241 | 1,541 | 121 | 11,166 |
| 1976 | 3,221 | 79,019 | 532 | 934 | 34 | 8,853 |

Source: FAO Fisheries Report 203 (Supplement 1).

certain countries. Table 5 summarizes the available data for recent years.

## Foreign Trade

Available data on imports and exports of hake products by country is not at present published in FAO statistical yearbooks. However, the general knowledge of hake flows from the major production areas to major markets is as follows.

The major hake markets are the United States and Europe, and to a lesser extent, Australia, Brazil, and some African countries. The United States consumes all the hake it produces and imports considerable quantities. The same is generally true for Europe, although Spain does export some hake. With European fish catches tending to level off and consumption of frozen fish growing there, we can expect to see larger imports of hake by Europe. Hake is being supplied to these markets from the beef-eating nations of South America and South Africa. Russia, which catches a large share of the world's hake also exports it, but the quantities are not available.

In most producing countries, domestic demand may well continue to rise. However, all countries attach the greatest importance to foreign trade for getting the most out of their resources and investments. FAO estimates of the major world import areas at present are shown in Table 6.

The present trade of 175,000 tons is the equivalent of about 440,000 tons of whole hake per year. We should add to this 15,000 tons of fresh hake imported by Brazil.

Out of a technically accessible market of 455,000 tons, Latin American trade accounts for 23 percent or 105,000 tons despite the fact that stocks and production capacity vastly exceed this figure. The remaining 77 percent is supplied by, in order of importance: U.S.S.R., Spain, Japan, South Africa, and Poland (Food and Agriculture Organization, 1978).

The spread of extended fisheries zones could drastically reduce the catches of German and Spanish long-distance fleets which catch about 150,000 tons of hake off West Africa.

**Table 5.—Partial production of hake products.**

| Product | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|---|---|
| Frozen fillets | | | | | | |
| U.S.A. | 0.2 | 0.1 | 1.3 | 0.9 | 0.4 | 0.4 |
| Argentina | 21.9 | 18.6 | 46.7 | 18.6 | 15.3 | 15.5 |
| Uruguay | — | — | — | — | 0.2 | 1.2 |
| S. Africa | — | — | — | — | — | 6.0 |
| Frozen miscellaneous | | | | | | |
| S. Africa | 9.2 | 9.2 | 23.5 | 18.9 | 25.2 | 39.4 |
| Argentina | 0.8 | 3.0 | 3.6 | 5.0 | 5.2 | 14.0 |
| Chile | 3.2 | 2.2 | 12.0 | 1.4 | 1.5 | — |
| Dried salted | | | | | | |
| Canada | 1.7 | 2.8 | 2.2 | 2.5 | 2.5 | 2.0 |
| Chile | 0.2 | 0.1 | 0.1 | — | — | — |
| Argentina | — | — | — | 0.5 | 0.1 | 0.2 |
| Smoked | | | | | | |
| Canada | 6.1 | 0.2 | 0.2 | 0.2 | — | — |

Source: FAO Yearbook of Fishery Statistics, various volumes.

**Table 6.—Current and projected world trade in hake products (tons).**

| Area | 1976-77 | 1980 |
|---|---|---|
| United States | 20,000 | 35,000 |
| Western Europe and Mediterranean | 121,000 | 185,000 |
| Australia | 15,000 | 20,000 |
| Brazil | 5,000 | 10,000 |
| Other Countries | 14,000 | 20,000 |
| Totals | 175,000 | 270,000 |

Source: FAO Fisheries Report 203 (Supplement 1).

The same restrictions will affect the Soviet, Japanese, and Polish factory ships. Thus, world trade could go up by as much as 300,000 tons to meet these demands.

FAO projects the international market for hake to be about 270,000 tons by 1980 (Table 6). This total is equivalent to an annual hake catch of 678,000 tons.

## Markets

### Spain

An important recent development in Spanish fisheries was the establishment of fisheries for Cape hake in the South Atlantic where fish were frozen on board and brought back to Spain either by the fishing vessels themselves or by specialized cargo boats. With a substantial portion of the catch coming from distant waters, the Spanish fishing industry faces a difficult time. Cape hake is now fully exploited (Earl R. Combs, Inc., 1979).

Hake has replaced cod as the major species landed, representing about 12 percent of Spain's total catch by weight.

About 45 percent of the Spanish fish catch is marketed fresh or chilled. The entire catch of Cape hake is marketed frozen in comparison with locally caught hake which is retailed fresh.

Early attempts, about 1959, to introduce frozen headed and gutted hake led to a strong adverse consumer reaction. The second step came with fillet production. To improve quality, filleting was done on board vessels. The introduction of battered, breaded, and fried products made from imperfect hake fillets was not successful. The Spanish market resisted products with a regular geometric shape. Now there is a growing market in prepared products from hake blocks sold in an aluminum tray with a sauce. The future for frozen hake in Spain is good (Varona, 1978).

### West Germany

The West German market for headed and gutted hake is rather limited, but with the increasing scarcity of other fish, there is a growing trend to replace them with blocks of frozen hake. Hake block imports are about 10,000 tons at present (Food and Agriculture Organization, 1978). Imported hake blocks are cut and processed as fish sticks and packaged into convenience sizes. The German consumer does not have a very clear concept of hake. For this reason, firms lean toward other species when the hake supply is inadequate (Werner, 1978).

The introduction of extended fishing zones has wreaked havoc with the German fishing industry by depriving it of, or severely limiting, catches on its traditional fishing grounds. Consequently Germany will have to depend increasingly upon imports (Earl R. Combs, Inc., 1979).

### France

Hake is well received on the French market which totals about 20,000 tons per year. Imports from South America

total about 4,000 tons. The French market remains essentially a fresh fish market for only one-third of French households have freezers. Although frozen and smoked seafoods are making slow but gradual inroads, the French consumer ordinarily purchases entire or sectional fish or increasing amounts of fillets (Earl R. Combs, Inc., 1979).

**Portugal**

Hake is one of the most popular species in Portugal. The production of cod is not able to keep up with market demand, thus hake is being substituted. Hake imports were 17,000 tons in 1976 and 10,000 tons in 1977 compared with catches of 19,000 and 35,000 tons in those years. The largest share of imported hake comes from South Africa and the U.S.S.R. The Amessao Reguladora de Commercio de Bacalhar (Regulatory Commission for Cod Trade) is able to import hake only when the domestic catch is insufficient to meet market demand (Earl R. Combs, Inc., 1979).

**Italy**

Hake is one of the most important fish sold at retail in Italy. The market for hake is estimated at 90,000 tons (Fishery Development Ltd., 1974).

**Brazil**

There is a considerable Brazilian market for dried salt fish with 40,000 tons imported annually. Consumption ranges from 85,000 to 100,000 tons. The traditional cod and related species are being replaced, in part, by lower cost dried salted hake (Food and Agriculture Organization, 1978).

**Zaire**

The total market for dried salted fish is about 30,000 tons. Supplies from northern Europe are becoming scarce and more costly. Some hake is imported from Latin America (Food and Agriculture Organization, 1978).

**Australia**

Australia imports about 4,000 tons of smoked hake and also frozen blocks from South America (Food and Agriculture Organization, 1978).

**United States**

Frozen fish blocks of various species are extensively used in the United States as raw materials for further processing into a wide variety of products (Table 7). Block use has grown at a rate of 6 percent per year in the 1970's. Hake blocks have received increased attention in the United States, mainly as a substitute for cod blocks. Hake is gradually meeting with the acceptance of the industry because of certain resemblances with cod and other popular white flesh species (Pedraja, 1978). In 1978, hake accounted for nearly 10 percent of U.S. imports of frozen fish blocks. Imports of hake blocks in recent years have increased from 4 million pounds to 10 million pounds (Table 8).

The two major market forms of whiting products produced in the United States are fillets and headed and gutted fish (Brooker, 1978). Production of these products has been declining over the last 10-15 years (Table 9).

**Table 7.—U.S. imports of fish blocks by species, 1978.**

| Species | Tons | Percent of total |
|---|---|---|
| Cod | 92,833 | 50.4 |
| Pollock | 36,868 | 20.0 |
| Haddock | 12,257 | 6.6 |
| Flatfish | 7,609 | 4.1 |
| Hake | 18,058 | 9.8 |
| Ocean perch | 1,399 | 0.7 |
| Minced fish | 9,007 | 4.9 |
| Other | 6,454 | 3.5 |
| Total | 184,485 | 100.00 |

Source: Fisheries of the United States, 1978.

**Table 8.—U.S. imports of hake blocks.**

| Year | Tons |
|---|---|
| 1975 | 3,954 |
| 1976 | 9,362 |
| 1977 | 10,160 |
| 1978 | 18,058 |

Source: Fisheries of the United States, 1978.

**Table 9.—U.S. production of hake products (tons).**

| Year | Headed and gutted | Fillets |
|---|---|---|
| 1968 | 15.5 | 1.0 |
| 1969 | 7.6 | 1.0 |
| 1970 | 7.0 | 0.3 |
| 1971 | 4.6 | 0.8 |
| 1972 | 2.4 | 0.1 |
| 1973 | 4.6 | 1.3 |
| 1974 | 2.0 | 0.8 |
| 1975 | 3.9 | 0.4 |
| 1976 | 4.5 | 0.4 |
| 1977 | 3.9 | 0.4 |

Source: Processed Fishery Products, NMFS, various years.

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# South American Hakes: The Resource And Its Utilization

GEORGE G. GIDDINGS

## Introduction

The subject of this paper is the several hake and hake-like species of the order Gadiformes that occur in the waters of Peru, Chile, Argentina, and Uruguay (plus the southern extremities of Brazil and Ecuador), and that are harvested by industries of these four nations, in some instances in cooperation with joint venture partners from abroad.

Starting with Peru and moving counterclockwise, the species of interest are: *Merluccius gayi peruanus* (Peruvian silver hake/whiting); *Merluccius gayi gayi* (Chilean silver hake/whiting); *Merluccius polylepsis* ("Merluza del Sur or-española"—southern Chile); *Macruronis magellanicus* ("Merluza de cola", grenadier) harvested in southern Chile and Argentine waters; *Micromesistius australis* ("Merluza de tres aletas" in Chile, "polaca" in Argentina), southermost of the South American hake-like species, extending from waters in the extreme south of Chile and Argentina out around the Falkland or Malvinas Islands and down into the sub-Antarctic; and, *Merluccius hubbsi*, shared among Argentina and Uruguay and commonly referred to as Patagonian hake/whiting.

Based upon current, and in some cases rather preliminary resource estimates, exploitation of these stocks to their full potential would in all probability allow combined total annual landings well in excess of 1 million metric tons(t) annually. Assumming foreign markets continue to be reasonably strong, most of this can be expected to continue to be exported abroad in several frozen forms, including blocks. Further, quality of these intermediate products should continue to improve with improvements in vessels and in post-harvest/processing.

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## Peru

The Peruvian fishing industry continues to develop following the fundamental policy changes of the present government, which took power in 1975. Peru's hake resource is to be harvested increasingly by vessels under local private ownership to supply a rapidly expanding number of shore plants, rather than by large foreign trawlers under government-to-government joint ventures. Under such ventures Poland and Cuba distributed 75 percent or more of the Peruvian hake catch directly abroad. Their factory trawlers plus a few from other nations had been harvesting on the order of 100,000 t, more or less, during the past 5 years. Recently, the Cuban joint venture was allowed to expire followed by removal of their vessels, and local firms intend to purchase and operate the Polish trawlers and continue to use their established overseas market.

The most agreed upon estimate of the maximum allowable annual catch of Peruvian *Merluccius gayi,* which is separated by roughly 2,000 miles from the Chilean *M. gayi* stock, is on the order of 200-250,000 t. This could prove quite conservative if the recent Peruvian Marine Institute estimate of a several million ton standing hake stock is borne out. In any event, it will probably be a good while before Peruvian industry will be capable of exploiting hake at the 200-250,000 t level. Current indications are that 1979 hake statistics would be similar to 1978 for Peru.

Besides being relatively soft-textured and deterioration-prone, as is true of merluzas in general, Peruvian hake seems to be more heavily parasitized than comparable stocks, although this is not entirely clear. The Japanese have had trouble making acceptable surimi and gel products from it, and appear to have abandoned their effort there for this and/or other reasons. However, with proper post-harvest handling, processing, and storage, good quality intermediate frozen products (blocks, fillets, butterfly cuts, etc.) can and have been produced. The Peruvian Ministry of Fisheries has had an effort underway aimed at directing a significant percentage of the landed hake catch to finished products for domestic consumption, over and above the modest amount of fresh hake consumed. These include salted, dried and minced hake products, which are produced mainly at the expense of hake meal production which has been declining. As the reoriented Peruvian hake activity develops and grows it is

reasonable to expect that much or most of the catch will continue to be converted into frozen products for export to receptive overseas markets. Precisely which markets should continue to depend at least in part, and in the near term on who, if any, will be the joint venture partners. Additionally, the usual market determinants such as form, quality and volume demanded, and price should exert their collective influence. The same holds for Chile, Argentina, and Uruguay whose near-term hake outlook appears somewhat clearer than that of Peru.

## Chile

In general, of the four subject countries Chile has the most established and diversified seafood processing industry, notably canned pelagics and canned and frozen mollusks and crustaceans. Hake is a more established domestic fresh market commodity in Chile than in the other three, and finished hake products are fairly commonplace. For example, one plant produces batter-breaded sticks and portions for local distribution and a frozen boil-in-the-bag product with sauce. Several retail frozen-branded merluza in fillet and small block forms. The major portion of the total hake catch by Chilean wetfish trawlers plus foreign factory trawlers enter international trade in frozen intermediate forms, however.

The common Chilean hake, *Merluccius gayi gayi,* has centered itself further south in recent years, no doubt due in part to heavy exploitation in the central zone of it, and of langostino and other species upon which it feeds. Also, landings which peaked at over 100,000 t in the late 1960's have fallen off sharply in recent years. However, the stock has become less accessible to the Chilean fleet and may not have diminished proportionately with diminished landings. Known for its considerable vertical and north-south migrations, *M. gayi* is presently trawler-fished mainly below lat. 37°S, much further south than in the past.

Following the decline in *M. gayi* landings there has been a recent upsurge in the harvest of *M. polylepsis* (merluza del sur, or-española) the largest and perhaps best of the South American hakes, reaching well over 100 cm and 10 kilos. This species is harvested from below lat. 40°S to waters down around Cape Horn (lat. 57° S), along with *Macruronis magellanicus* (merluza de cola or grenadier), and *Micromesistius australis*. The latter is called "merluza de tres aletas" in Chile and "polaca" in Argentina. It is also referred to as southern blue whiting, although larger, and easier to process than North Atlantic blue whiting.

All three of these newly exploited hake resources, plus other demersals are mainly harvested by Japanese factory trawlers which must operate below lat. 43°S. The most recent decree, signed on 28 March and published in the Chilean equivalent of the U.S. *Federal Register* on 9 April 1979, allows for a combined total harvest of 70,000 t below lat. 43°S between 1 April and the end of 1979, when the matter was to be reviewed, and either continued as is or revised.

There is a growing sentiment within the Chilean industry against the presence of foreign factory ships in the south; however, the government continues to favor such arrangements partly on grounds that the waters would not otherwise be fished and assessed. The Chilean Fisheries Subsecretariat is quite conservation/management-minded, and the same holds for Argentine and Uruguayan government fishery regulators who are taking a cautious, measured approach to expansion.

Preliminary biomass estimates of the three newer species below lat. 43° S are 120,000 t for *Merluccius polylepsis,* 210,000 t for *Macruronis magellanicus,* and less than 100,000 t for *Micromesistius australis*. The present estimated combined total allowable equilibrium catch for the three species is put at about 100,000 t, which could be increased as more reliable catch-per-unit-effort data and the like is gathered and evaluated. To this is added the sustainable annual catch of *Merluccius gayi* which is not specified under the aforementioned decree law since very little *M. gayi* is believed to exist below lat. 43° S. It is presently put at on the order of 75,000-100,000 t. Again, the combined annual landings of the four Chilean hake-like species largely enter the international trade as on-board and on-shore frozen blocks, IQF fillets, etc. The remainder is marketed internally, both fresh and as processed products. Most recently, the latter include minced hake products developed by Foundation Chile for school lunch and other institutional feeding systems.

This pattern of utilization can be expected to continue, and future increases in the harvest of Chilean hakes will in all likelihood go primarily to production of frozen semiprepared products for receptive export markets. Besides the introduction of foreign factory trawlers in the far south of Chile, investments in new shore-based shellfish and finfish processing and freezing capacity has increased sharply within the last few years in the southern regions. There have been insufficient wetfish vessels to supply the newer plants especially, but additional vessels are gradually being introduced and the total fishing effort in the waters of southern Chile can be expected to continue to increase.

## Argentina

Although *Macruronis magellanicus* and *Micromesistius australis* (and possibly *Merluccius polylepsis* stocks, as well as nonhakes) extend over into Argentine waters, there is no fisheries agreement between Chile and Argentina; in fact, the maritime boundary between the two at the tip of the continent below the Tierra del Fuego is a matter of active dispute. The steadily increasing Argentine fishery activity reached 500,000 t landings in 1978, led by hakes which accounted for 68 percent of the total.

Phase one of a two-step national fishery development plan is expected to be completed in 1982 with the achievement of a 1,000,000 t annual landing. Seventy-five percent of this is to be hake (mainly *M. hubbsi* plus *Macruronis magellanicus* or "polaca"). To this end, additional vessels and shore

plants are being phased in both at new ports, and at existing ports which are undergoing improvement.

Notable in the latter case is Mar del Plata which has been the principal fish landing and processing port. Upon reaching the 1-million-t total in 1982, provided harvesting and processing capacity is adequate by then, this limit will be reevaluated, and could be raised to as high as 2 million t total if indications are favorable.

Contributing in a major way to phase one development are joint ventures with about 10 Spanish companies, a consortium of 5 Japanese firms and another with 4 West German firms. To focus the development in the southern provinces, no further companies are being licensed to fish above lat. 40°S. New plants will be allowed to be located between lat. 40° and 46°S; however, they must fish below lat. 46°S.

During phase one, the approximately 21 freezer trawlers now present will be allowed to increase to 26, and the 16 factory ships to 24. In addition, the number of various sized wetfish trawlers and seiners are to reach around 200, in addition to over 200 coastal boats. Port development is intended at favorable locations along the coast, principally below lat. 40°S, and as far down as Ushuaia on the Beagle Channel's north shore at about lat. 55° S, a project that is well underway.

The only more southerly seafood processing port on earth is Puerto Williams, across the Beagle Channel from Ushuaia on the Chilean island Navarino. King crab is the principal resource of interest in that remote area. Puerto Madryn, on a large sheltered bay at about lat. 43°S appears destined to become the base for the Japanese trawler fleet, and, assuming the West Germans extend their venture, theirs as well.

Utilization of Argentine hake landings continues to be dominated by preparation of frozen semiprepared items (blocks, fillets, etc.) for export to Europe, the Orient, and North America in that order volumewise. Approximately 150,000 t of frozen product, most of it from hakes, was exported in 1978. This figure was expected to double in 1979; and in 1982, the final phase-one year, around 500,000 t of frozen product is projected to be exported. Hakes will continue to account for most of this, as they must make up 75 percent of the total harvest according to the Subsecretary of Fisheries–State Secretary for Maritime Interests, which regulates commercial fishing activity.

Estimates of the hake biomass in Argentine waters range from the FAO estimate of 1-1.5 million t to the 6 million t or more Soviet estimate. However, much more data needs to be, and is being, gathered and analyzed, especially in southern waters, and the true standing stock of all hakes off Argentina is perhaps somewhere between the two estimates.

The *Merluccius hubbsi* stock in particular exhibits a wide seasonal migration, being concentrated above lat. 40° S during the winter months of June-September when it is readily accessible to the Mar del Plata and Uruguayan fleets. During the summer months from about November into March, *M. hubbsi* is concentrated well below lat. 40°S, and between the seasons it makes its north-south, south-north migrations.

This has contributed significantly to product quality problems whereas during the warmer months of the year the fleet is well to the north of the main hake stocks, requiring turn-around trips of several days for wetfish trawlers. Boxing onboard with ice is a rather common practice now, and as port and processing facilities increase below lat. 40°S and more modern wetfish vessels are phased in the situation should improve further. In general, handling, processing and quality assurance practices are improving to meet the challenge of exporting high quality products from a difficult resource to the more demanding and lucrative markets.

### Uruguay

The "newcomer" to hake fishing has made considerable strides in a relatively brief period of a few years. The Uruguayan industry features new plants and vessels, and, a high degree of emphasis on quality assurance under the National Fishery Development Plan of 1974, which is under the direction of the National Fishery Institute, created in 1975.

As with Argentina, the industry of Uruguay must obtain a license from the State to introduce new vessels and plants. Under the Treaty of Río de la Plata and its Maritime Front, the two countries share a common fishing zone extending east 200 nautical miles from the wide mouth of the Río la Plata which encompasses about two degrees of latitude in the north-south direction.

Except in the summer months of December through February when *M. hubbsi* is centered south of the practical range of the Uruguayan fleet, this zone plus adjacent waters are quite rich in *M. hubbsi*. Brazil typically takes from 20,000 to 40,000 t of *M. hubbsi* from waters off its southern extreme above Uruguay, but virtually entirely for internal consumption.

Under the first phase of the Uruguayan plan which is to be fulfilled during the decade of the 1980's, some 64 new wetfish trawler/seiners, 29-33 m in length, are to be phased into the fleet to supply shore processing plants at the capital of Montevideo, nearby Piriápolis, and La Paloma to the northeast.

La Paloma is being developed into a major port destined to support ten processing plants plus associated vessels by 1990. By this time, 100,000 t of raw material is projected to be landed there, with another 100,000 to be landed at Montevideo, which is to undergo port improvement and further plant expansion. Uruguay's fishery development plan is oriented entirely toward land-based processing, whereas the governments of Argentina and Chile feel the need for foreign factory trawlers, in the near term at least, to open up their remote and difficult southern offshore waters to commercial fishing.

Of the Uruguay phase one target of a 200,000 t total landing, approximately half, or 100,000 t, is to be *M. hubbsi*, mainly for processing into frozen interleaved and laminated blocks, fillets, H&G, etc. for export, with emphasis on the North American market. In

1978, a total of 74,200 t was landed by the Uruguayan fleet, nearly all at Montevideo. Of this, 56 percent was *M. hubbsi*, the remainder consisting of croaker, seatrout, anchoita, squid, and others that Uruguay and Argentina also share. The 74,200 t total landing generated 40.3 t of product for market, of which 79 percent was frozen forms, nearly all for export. This percentage has been increasing at an annual rate of 10 percent and more.

As with the other frozen hake exporters of South America, depending upon market requirements, blocks and fillets are shipped skin-on, regular skinned or deep skinned (''defatted''), boneless or pinbone in, etc. Like the better plants in the other countries, the Uruguayan plants give attention to such details as deparasitizing, removal of belly flaps, black membranes, residual bones, and, to good technique in making up laminated blocks for freezing.

In general, post-harvest handling is continually improving, with boxing on board with ice for rapid chilling, minimizing physical damage, and expediting transfer from vessels to plants becoming quite commonplace. In the case of wetfish trawlers the size of the vessels and the hauls has precluded heading and/or gutting onboard in Uruguay as well as the others.

## Summary

In summary, it can be said that the four South American countries possess considerable resources of hake/whiting and like species. While there is ample room for further progress, their industries are increasingly meeting the challenge of handling, processing, and distributing comparatively delicate, deterioration-prone fish in such a way as to meet the requirements of the most demanding importers, in large measure with the assistance of the importers themselves. Presently, and in the forseeable future, the emphasis is on hakes as foreign exchange earners; however, should the time come, the emphasis could be shifted to exploiting these very large resources as a major source of protein for their own and neighboring populations.

# The Silver Hake Stocks and Fishery off the Northeastern United States

E. D. ANDERSON, F. E. LUX, and F. P. ALMEIDA

*ABSTRACT–Three stocks of silver hake,* Merluccius bilinearis, *are presently defined for management purposes off the northeastern coast of the United States. The historical development and current status of the fishery is reviewed. Total international landings from the three stocks increased from 55,000 tons in 1960 to over 350,000 tons in 1965, but have fluctuated at lower levels since and were only 43,000 tons in 1978. Landings, fishing patterns, and management regulations are reviewed for each stock since 1955. Estimates of stock biomass from virtual population analysis indicate a general rebuilding of the resource since 1970. Current levels of harvest in relation to available surplus stock indicate the potential for major expansion of the U.S. silver hake fishery. Some of the implications associated with such an expansion are discussed.*

## Introduction

The silver hake or whiting, *Merluccius bilinearis,* stocks inhabiting the Continental Shelf waters off the northeastern coast of the United States have supported active commercial fishing since the 1930's. Fishing was conducted exclusively by the United States until distant water fleets from the U.S.S.R. began catching silver hake on Georges Bank in 1962.

Total international landings (commercial and estimated recreational) of silver hake from the Gulf of Maine to the Middle Atlantic increased from about 55,000 tons (100 percent U.S.) in 1960 to a peak of over 350,000 tons (15 percent U.S.) in 1965 and then declined sharply to again about 55,000 tons (40 percent U.S.) in 1970. Landings during 1971-75 averaged about 121,000 tons (15 percent U.S.), decreased to about 82,000 tons (31 percent U.S.) in 1976-77, and dropped further to 43,000 tons (67 percent U.S.) in 1978.

Distant water fleet catches have diminished steadily since 1973 due in part to quota limitations implemented beginning that year by the International Commission for the Northwest Atlantic Fisheries (ICNAF) and to further restrictions imposed by the United States beginning 1 March 1977 as a result of the Fishery Conservation and Management Act (FCMA). United States landings have improved slowly since 1974.

Edwards (1968) estimated that silver hake comprised the largest standing crop of any species in the offshore area between the Nova Scotian shelf and the New York Bight in 1963-65. Based on current assessments of the status of the stocks in this area (Resource Assessment Division[1]), it still maintains that supremacy at the present time. By virtue of the available biomass and the current level of landings, silver hake must be classified as an underutilized species.

This paper describes the distribution and stock definition of silver hake off the northeastern United States, reviews the historical development and current status of the fishery, describes the past and present stock size estimates, and discusses some of the possible implications of an expanded U.S. silver hake fishery.

## Distribution

The silver hake occurs in Atlantic continental shelf waters between Newfoundland and South Carolina and is most abundant between Cape Sable, Nova Scotia, and New York (Bigelow and Schroeder, 1953). In U.S. waters, it is abundant from Maine to New Jersey. Silver hake is also abundant on the Nova Scotian shelf in Canadian waters and supports a large, primarily U.S.S.R. fishery. The pattern of distribution varies with season and area. Throughout the winter off New England, it is found primarily in deeper waters near the outer edge of the continental shelf and in deep basins in the Gulf of Maine where the water is warmer than inshore. In the spring and summer as the coastal waters warm, there is a general, though incomplete, shoreward movement with the main concentrations of fish being found in waters of about 20-80 m. Some silver hake move into shallow beach areas. Farther south in the New York Bight, the seasonal pattern is somewhat different. Fish are present in inshore waters from late autumn to spring and then move more into southern New England waters during the spring and summer.

## Stock Definition

The silver hake inhabiting waters off the northeast coast of the U.S. are pres-

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[1]Resource Assessment Division. 1978. Summary of stock assessments August 1978. Woods Hole Lab. Ref. 78-40, 26 p., on file at Northeast Fisheries Center Woods Hole Laboratory, Woods Hole, Mass.

ently grouped into three stocks according to divisions and subdivisions of ICNAF Subarea 5 and Statistical Area 6. These are: 1) The Gulf of Maine (Div. 5Y) stock, 2) the Georges Bank (Subdiv. 5Ze) stock, and 3) the southern New England-Middle Atlantic (Subdiv. 5Zw and Statistical Area 6) stock (Fig. 1). These delineations reflect, to some extent, scientific information concerning stock identification, but resulted primarily within ICNAF from a need to assess and manage based on the areas by which catch statistics were reported.

There is some evidence that silver hake in the area between the Gulf of Maine and Cape Hatteras consist of several discrete stocks. Conover et al. (1961) examined morphometric measurements and found no significant differences between fish from the inshore Gulf of Maine and the northern part of Georges Bank nor between fish from the southern New England and the Middle Atlantic areas, but did find highly significant differences between fish from the Gulf of Maine-northern Georges Bank area and the southern New England-Middle Atlantic area. Tagging studies were conducted in 1957-58 in the Gulf of Maine-Georges Bank area and off New Jersey (Fritz, 1959), resulting in only a 4.3 percent recapture rate (Fritz, 1963). The recaptures occured fairly close to the tagging sites (the greatest distance traveled was 65 km), indicating the lack of any significant movement of silver hake from one area to another.

Nichy (1969) examined first-year growth patterns on otoliths from young silver hake and found a difference in otolith zonal formation and length at age between fish north and south of lat. 41°30′N. Recent calculation of growth parameters using age-length data from the Gulf of Maine, Georges Bank, and southern New England-Middle Atlantic areas (Almeida[2]) indicated that fish in the Gulf of Maine grow faster and attain greater lengths than those to the south.

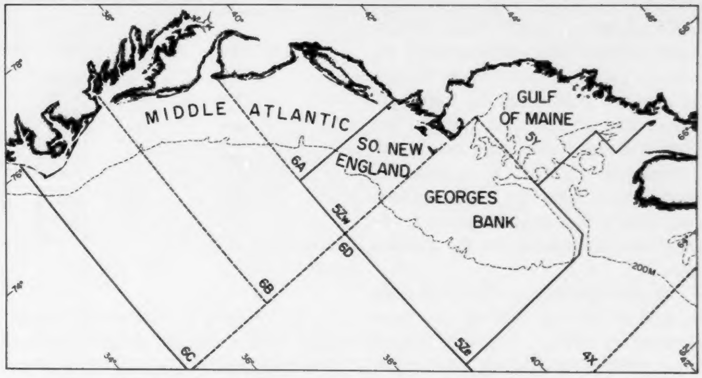



Figure 1.—Fishing grounds off northeastern U.S. and the divisions and subdivisions of ICNAF Subarea 5 and Statistical Area 6.

Konstantinov and Noskov (1969) reported that serological analysis had distinguished one silver hake stock in the Georges Bank area and another in the Cape Cod-Cape Hatteras area, with an approximate division in the Nantucket Shoals area (Subdiv. 5Ze and 5Zw boundary area) and some mixing of the two groups during autumn and winter.

Examination of the seasonal distribution of silver hake catches during U.S. research vessel bottom trawl surveys (Anderson, 1974) suggests that fish which summer in the inshore portions of the Gulf of Maine and along the northern part of Georges Bank appear to overwinter in the deep areas of the Gulf of Maine, and fish which occupy the southern part of Georges Bank in the warm months overwinter in deep water along the southern edge of the Bank. Fish in the southern New England-Middle Atlantic area undergo a seasonal inshore-offshore migration. Survey catches indicate a generally continuous distribution of fish from the southeastern part of Georges Bank to the Middle Atlantic area and show no apparent division between a Georges Bank stock and a southern New England-Middle Atlantic stock.

Examination and consideration of all available information suggests the possibility of a Gulf of Maine-northern Georges Bank stock and another stock (maybe two) extending from southern Georges Bank to the Middle Atlantic area. However, scientific evidence is presently not sufficient to define separate spawning stocks which are genetically distinct. Results from additional studies planned or in progress, such as morphometric-meristic analysis, biochemical analysis, and tagging, must be examined before further conclusions can be drawn. In the meantime, providing that traditional fishing areas and patterns do not change substantially, the present stock delineations are satisfactory for management of the resource.

## Fishery

### Historical Development

The U.S. silver hake fishery apparently began in the early 1840's (Fritz, 1960). Prior to the early 1920's, landings were less than 7 million pounds (3,175 t) annually, and the species was considered a nuisance. However, in the early 1920's, a market was developed in St. Louis, Mo., for fried fish shops (Johnson, 1932), which purchased a quarter of the Atlantic coast yearly landings. Technological advances in handling, freezing, processing, and transportation further aided in creating markets and developing the fishery.

During the early days of the fishery, when it was an inshore operation, the

[2] Almeida, F. P. 1978. Determination of the von Bertalanffy growth equation for the southern New England-Middle Atlantic, Georges Bank, and Gulf of Maine stocks of silver hake. Woods Hole Lab. Ref. No. 78-13, 15 p., on file at Northeast Fisheries Center Woods Hole Laboratory, Woods Hole, Mass.

pound net was the principal gear (Fritz, 1960). After an active U.S. fishery began in the 1930's and operations extended offshore, the otter trawl became the primary gear. Floating traps, gill nets, purse seines, line trawls, and other gear have also been employed. Virtually all of the U.S. commercial catch is now taken by otter trawlers, with vessels less than 50 gross registered tons accounting for the greatest share.

The principal silver hake port since the end of World War II has been Gloucester, Mass., whereas Boston was formerly the leading one (Fritz, 1960; O'Brien, 1962). Catches from the Gulf of Maine-Georges Bank area have been landed at Gloucester and numerous other ports including Portland, Maine; and Provincetown, Mass. Catches from southern New England waters have been landed mainly at Point Judith, R. I., and those from the Middle Atlantic at Freeport, Long Island; and Point Pleasant and Belford, N.J.

Silver hake have been utilized commercially in many ways (Fritz, 1960; O'Brien, 1962). They have been processed largely for human consumption and sold as a frozen product in the headed and gutted form and to a lesser extent as fillets and fresh fish. They have also been marketed frozen as mink food and processed as canned pet food. Additional quantitites of silver hake, generally those too small or otherwise undesirable for processing as a food product, have been processed into fish meal for use as poultry and cattle feed supplements. The latter use developed as a result of a specialized trawl fishery which began in 1949 in New England waters to supply fish, which were otherwise not marketable, for reduction or industrial purposes (Snow, 1950; Sayles, 1951; Edwards, 1958a; Edwards and Lux, 1958). A large part of the industrial catch, 15-40 percent depending on area and season, consisted of silver hake (Edwards, 1958a). New England silver hake landings for reduction were estimated to be about 18,000 tons in 1957 (Edwards, 1958b), 10,000 tons in 1958 (Edwards and Lawday, 1960), and peaked at close to 20,000 tons in 1964 (E. D. Anderson, unpubl. data). The reduction fishery declined after the early 1960's as a result of imports of fish meal from South America and is no longer of importance. Estimated silver hake landings for reduction have averaged less than 1,000 tons annually since 1970.

Table 1.—Landings of silver hake by state off northeastern U.S. in 1968-77, in metric tons.

| Year | Maine | Mass. | Rhode Isl. | New York | New Jersey | Total |
|---|---|---|---|---|---|---|
| 1968 | 13,114 | 18,365 | 985 | 1,501 | 1,834 | 35,799 |
| 1969 | 8,113 | 8,326 | 1,286 | 967 | 1,736 | 20,428 |
| 1970 | 6,729 | 9,792 | 1,631 | 462 | 1,497 | 20,111 |
| 1971 | 4,490 | 6,838 | 1,320 | 480 | 1,790 | 14,918 |
| 1972 | 1,857 | 5,092 | 1,248 | 1,193 | 2,467 | 11,857 |
| 1973 | 2,593 | 11,553 | 1,403 | 875 | 2,925 | 19,349 |
| 1974 | 1,301 | 5,609 | 2,367 | 887 | 3,184 | 13,348 |
| 1975 | 543 | 12,077 | 2,425 | 1,179 | 2,933 | 19,157 |
| 1976 | 185 | 13,351 | 3,303 | 1,155 | 3,590 | 21,584 |
| 1977 | 116 | 12,326 | 2,492 | 955 | 4,560 | 20,449 |

There is also a recreational hook-and-line fishery for silver hake from southern Massachusetts to New Jersey. Fish are caught from subtidal waters out to depths of approximately 45 m. The catch is greatest in New York-New Jersey, with the bulk taken during late autumn-early spring by both shore-based anglers and from boats (charter, party, and private). During this season, silver hake is very important to the recreational fishery due to its availability at a time when very few other species are present inshore. Marine angler surveys in 1960, 1965, 1970, and 1974 (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973; Deuel[3]) estimated the recreational silver hake catch to be 1,801, 2,717, 950, and 1,075 tons, respectively, in those years. Results from National Marine Fisheries Service (NMFS), Northeast Fisheries Center creel surveys in the New York Bight area in 1975-77 gave estimates of 197, 1,706, and 3,948 tons, respectively, for those years.

### Current Trends by State

Commercial landings of silver hake in the principal states during 1968-77 are given in Table 1. Maine landings fell sharply from over 13,000 tons in 1968 to only 116 tons in 1977. This condition apparently was brought about by a shortage of fish and rather poor markets in the early 1970's. These factors led to the closing of the silver hake processing plants in Portland. Increased supplies and a better market environment are needed to revive this Maine fishery, which has been directed for silver hake.

Massachusetts is the leading State in silver hake landings (Table 1). Landings have varied between 5,100 and 18,400 tons during 1968-77 with improved landings in 1975-77. The fishery for silver hake, primarily out of Gloucester, is largely directed.

Silver hake landings in Rhode Island rose from 985 tons in 1968 to about 3,000 tons in 1976-77 (Table 1). The fishery is for a mixed catch of trawl-caught species which includes silver hake, although there sometimes are directed silver hake trips as well, depending upon market conditions.

Landings of silver hake in New York have averaged around 1,000 tons during 1968-77 (Table 1). In New Jersey, landings in 1968-77 ranged from 1,500 tons in 1970 to 4,600 tons in 1977. Landings in both New York and New Jersey result from directed silver hake effort. The principal grounds fished are in the New York Bight, mostly in depths inside of 45 m.

Average landings by month in 1975-76 for each of the above States are given in Table 2 to illustrate the seasonal character of the silver hake fisheries. Maine landings, although low in these 2 years, indicate a primarily summer fishery conducted mainly from June to October. In Massachusetts, the bulk of the landings in these years was data). The reduction fishery declined

[3]D. G. Deuel, Resource Statistics Division, National Marine Fisheries Service, NOAA, Washington, DC 20235, pers. commun.

**Table 2.—Average monthly landings of silver hake in 1975-76 by state, in metric tons.**

| Month | Maine | Mass. | R.I. | N.Y. | N.J. |
|---|---|---|---|---|---|
| January | 1 | 70 | 305 | 203 | 597 |
| February | 3 | 364 | 137 | 210 | 679 |
| March | 3 | 555 | 124 | 201 | 795 |
| April | 5 | 170 | 275 | 123 | 616 |
| May | 14 | 881 | 359 | 103 | 207 |
| June | 79 | 728 | 338 | 59 | 7 |
| July | 42 | 3,011 | 192 | 16 | 1 |
| August | 102 | 2,274 | 168 | 14 | — |
| September | 55 | 1,923 | 212 | 17 | 1 |
| October | 45 | 1,567 | 117 | 56 | 15 |
| November | 10 | 928 | 245 | 58 | 102 |
| December | 5 | 242 | 389 | 107 | 240 |
| Total | 364 | 12,713 | 2,861 | 1,167 | 3,260 |

during May-November. The situation in Rhode Island is somewhat different in that there are two principal seasons, although some silver hake are landed in each month. The first season is during April-June when fishermen say the silver hake are migrating eastward past the Rhode Island shore; the second is during November-January when fish are migrating westward toward their wintering grounds in the New York Bight. Almost all of the silver hake landings in New York and New Jersey are during November-May, when this species is most plentiful in the New York Bight.

### Current Trends by Stock

*Gulf of Maine*

Total landings during 1955-64 varied between 21,500 and 37,000 tons and averaged 29,700 tons (Fig. 2). Landings dropped from 31,700 tons in 1964 to 22,600 tons in 1965, and ranged from 24,700 to 11,400 tons during 1965-70 while averaging 18,300 tons. Landings continued to drop and averaged only 7,900 tons during 1971-78 while ranging between 5,200 (1974) and 9,800 (1976) tons; 1978 landings were 6,200 tons.

This fishery has been conducted almost exclusively by the United States (Fig. 3). In 1963 and 1971-75, small landings were reported by the U.S.S.R., Poland, Federal Republic of Germany, German Democratic Republic, and Bulgaria, which averaged about 10 percent of the total annual landings in those years (Fig. 3).

The total allowable catch (TAC) for this stock was set by ICNAF at 10,000

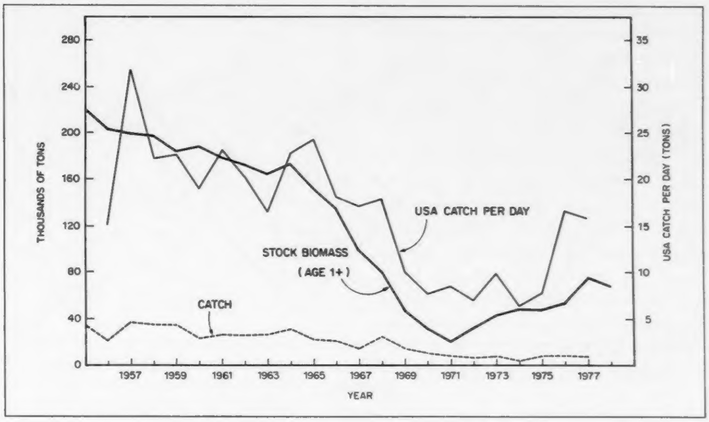
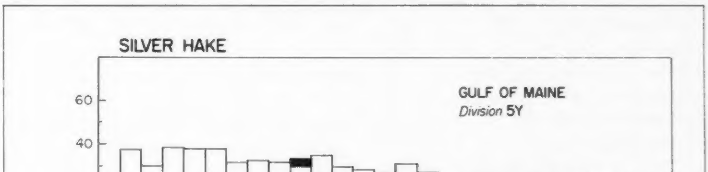



Figure 2.—International catch, stock biomass (ages 1 and older) from virtual population analysis, and U.S. commercial catch per day from the Gulf of Maine silver hake stock (Almeida and Anderson, 1979c).

Figure 3.—Total U.S. and foreign landings of silver hake from ICNAF Subarea 5 and Statistical Area 6 in 1955-78.



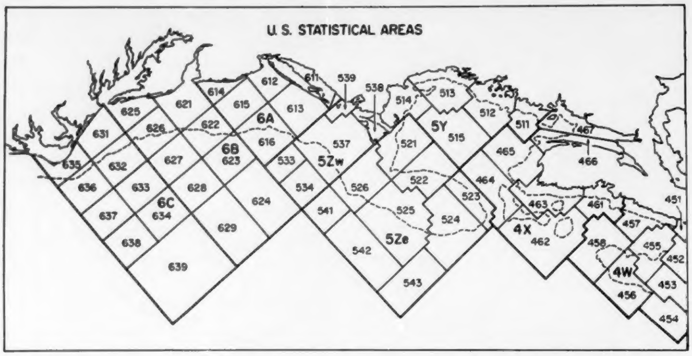



Figure 4.—U.S. statistical areas for the reporting of commercial fishery statistics.

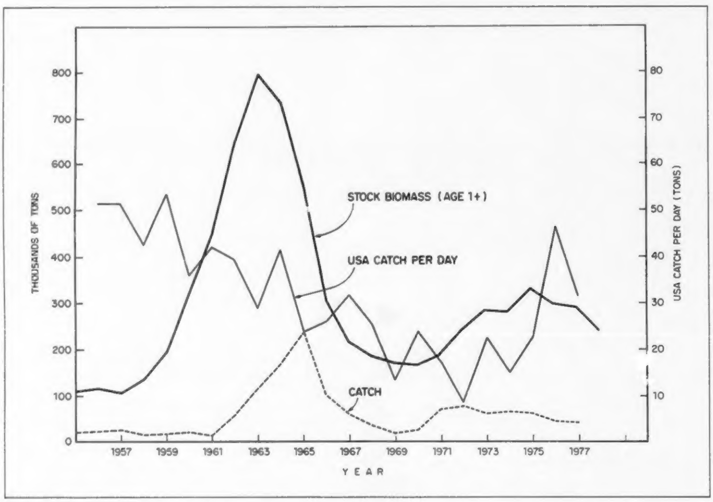



Figure 5.—International catch, stock biomass (ages 1 and older) from virtual population analysis, and U.S. commercial catch per day from the Georges Bank silver hake stock (Almeida and Anderson, 1979a).

tons for 1973-74, 15,000 tons for 1975, 10,000 tons for 1976, and 9,000 tons for 1977. This stock has not been under management regulation following implementation of the FCMA, and has been fished solely by domestic vessels.

The bulk of U.S. landings have traditionally been during May-December by small vessels fishing single-day trips in inshore areas, although there have been landings in all months since 1970. Prior to 1964, the most productive grounds were located in U.S. statistical area 514 (Fig. 4) which includes Stellwagen Bank, local grounds adjacent to Gloucester, and Cape Cod Bay. During 1964-73, statistical area 513 (Jeffreys Ledge to Casco Bay) provided the greatest catches. During 1974-77, area 514 again was the most productive area. In 1977, 80 percent of the Div. 5Y silver hake landings came from area 514, and 10 percent each from areas 513 and 515. In earlier years landings were reported from area 512, as high as 750 tons in 1969, but have decreased to only a few tons per year in the last 5 years. In the last several years, the inshore fishery has essentially begun in April instead of May, and during 1976-78 significant catches were taken from area 515 (deep over-wintering area) during the January-April period.

## *Georges Bank*

Total landings increased from an average of 19,000 tons during 1955-61 to nearly 239,000 tons in 1965 and declined rapidly to 18,400 tons in 1969 (Fig. 5). Landings increased and stabilized at an average of about 68,000 tons during 1971-75, but declined to 45,800 tons in 1976, 44,300 tons in 1977, and only 10,000 tons in 1978.

United States landings averaged 18,200 tons during 1955-63, but declined to average only 3,900 tons during 1968-78 (Fig. 3). Landings increased, however, from 3,700 tons in 1977 to 6,400 tons in 1978, the highest level since 1968.

During 1973-75, the ICNAF TAC was 80,000 tons each year. The 1976 and 1977 TAC's were 50,000 and 70,000 tons, respectively. As a result of FCMA, this stock was managed exclusively by the United States after 1 March 1977. The optimum yield (OY) established by the NMFS Preliminary Fishery Management Plan (PMP) for the Hake Fisheries of the Northwestern Atlantic was 58,800 tons in both 1978 and 1979. U. S. allocations of the 1973-77 TAC's were 17,000, 11,056, 11,100, 8,500, and 15,000 tons, respectively, whereas actual U.S. landings during this period averaged only about one-third of each year's allocation. The amount designated as U.S. capacity and reserved for U.S. fishermen in 1978 and 1979 was 26,000 tons.

Until 1969, statistical area 521 (Fig. 4), which lies immediately east of Cape Cod, produced the bulk of U.S. landings from Subdiv. 5Ze, with most of the fishery conducted during June-October. During 5 of the 8 years since 1969, area 522 on Georges Bank, which includes Cultivator Shoal, has

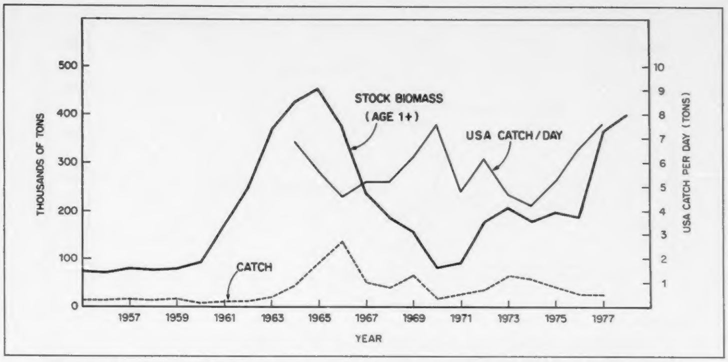



Figure 6.—International catch, stock biomass (ages 1 and older) from virtual population analysis, and U.S. commercial catch per day from the Southern New England - Middle Atlantic silver hake stock (Almeida and Anderson, 1979b).

outproduced area 521. U. S. fishermen have been catching silver hake from area 522 since 1955, primarily during June-September.

The distant water fleet (DWF) fishery for silver hake has been conducted primarily by the U.S.S.R. They have fished virtually all of Georges Bank for silver hake beginning in 1962 but have focused mainly along the southern part of the Bank in statistical areas 525, 526, and 524 (Fig. 4). The U.S.S.R. has also fished area 522 during the same months as the U.S. The seasonal pattern of the U.S.S.R. fishery has varied from year to year but has primarily been conducted during March-August. During 1962-77, about 77 percent of the landings occurred during those months. During 1973-76, March was the predominant month, averaging 30 percent per year of the total. In 1977, 84 percent of the U.S.S.R. landings were during April-June, with June having the largest share (37 percent).

Beginning in 1970, various conservation areas were established by ICNAF which closed parts of the area to the DWF hake fishery, in some cases for certain months and in other cases totally. In 1976, the U.S.S.R. stern trawler fleet for silver hake was excluded from most of Georges Bank by virtue of an ICNAF regulation banning the use of bottom trawls by vessels over 47 m (155 feet) in waters less than 73 mm (40 fathoms). Consequently, the U.S.S.R. fishery was confined to the southern slopes of the Bank. From 1 March to 30 June 1977, the DWF hake fishery in Subdiv. 5Ze was limited to a relatively narrow "window" extending between long. 67°W and 70°W along the edge of the continental shelf. The 1978 "window" was the same as in 1977, but with fishing allowed during April-June with bottom trawls and during March and October-December with pelagic gear only. In 1979, the "window" was reduced to extend only between long. 67°W and 68°45′W, and DWF fishing was permitted only during January-March with bottom trawls and August-December with off-bottom trawls.

*Southern New England-Middle Atlantic*

Total landings averaged about 16,800 tons during 1955-59, declined to 10,000 tons in 1960, and then improved steadily to 137,400 tons in 1966 (Fig. 6). Landings dropped sharply to 50,900 tons in 1967 and have since fluctuated between 19,200 and 67,000 tons. Landings increased steadily from 19,200 tons in 1970 to 66,000 tons in 1973 and then declined to an estimated 26,900 tons in 1978.

U.S. commerical landings during 1955-65 ranged between 8,200 and 25,000 tons (Fig. 3) and averaged about 14,800 tons per year, during which time the industrial fishery and market were strong. Landings during 1966-78 were much lower following the closing of a major reduction plant, ranging between 5,000 and 11,400 tons and averaging about 7,900 tons or about 21 percent of the total per year. The 1978 landings of 11,400 tons were the highest since 1965. Estimated U.S. recreational catches during 1955-77 ranged between 692 and 3,948 tons and averaged about 1,000 tons per year. Assuming the same ratio between U.S. commercial landings and recreational catches in 1978 as in 1977 implies a 1978 recreational catch of about 4,800 tons.

The ICNAF TAC for this stock was 80,000 tons per year during 1973-75, 43,000 tons in 1976, and 45,000 tons in 1977. The 1978 OY established by the NMFS PMP was 33,200 tons and was increased by 5,000 tons in mid-year (this increase was added to the DWF allocation). The 1979 OY was increased to 40,000 tons. U.S. allocations during 1973-77 were 25,000, 18,864, 18,900, 9,000, and 12,500 (plus 2,000 for the U.S. recreational fishery) tons, respectively. During 1973-75, U.S. landings averaged only 35 percent of the allocated amounts, whereas in 1976 the United States exceeded its allocation by 6 percent, and in 1977 U.S. landings were about 75 percent of the allocation. The amount designated as U.S. capacity in 1978 and 1979 was 20,600 tons.

The U.S. silver hake fishery in Subdiv. 5Zw is conducted throughout the entire year, although in most years peak landings have been during May-July. Statistical area 539 (Fig. 4) has, in most years, contributed the largest share from southern New England waters. The U.S. fishery in Statistical Area 6 (SA 6) is primarily in Div. 6A and is conducted mainly from November through May.

The DWF fishery on this stock, as with the Georges Bank stock, has been conducted primarily by the U.S.S.R. The U.S.S.R. has fished in all areas of Subdiv. 5Zw and SA 6, with the largest share in most years (11 of 15) coming from 5Zw. Landings have occurred in all months; however, the bulk (average

of 56 percent during 1963-77) has generally come during February-April, although during 1969-72 the largest amounts came during June-August. ICNAF conservation areas have restricted the DWF fishery both seasonally and areally. Additional restrictions were placed on the DWF fishery in SA 6 as a result of bilateral fisheries agreements. The 1977 DWF hake fishery in Subdiv. 5Zw + SA 6 was restricted to a "window" extending from the 5Ze-5Zw boundary west into Div. 6A along the edge of the shelf which was open only through March. The 1978 and 1979 DWF fisheries were confined to essentially the same area with fishing with bottom gear (which is needed to catch silver hake although some may be caught with pelagic gear) limited to January-March.

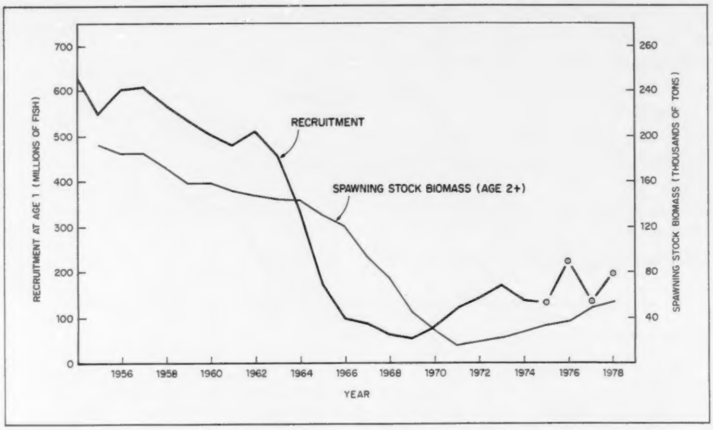



Figure 7.—Gulf of Maine silver hake spawning stock biomass (ages 2 and older) in 1955-78 and abundance at age 1 of the 1954-77 year classes. Open circles indicate estimated year-class sizes (Almeida and Anderson, 1979c).

## Status of the Stocks

### Gulf of Maine

Total estimated stock biomass (ages 1 and older) decreased from about 220,000 tons in 1955 to a low of only about 20,000 tons in 1971 (Fig. 2) and then increased to slightly over 75,000 tons in 1977 (Almeida and Anderson, 1979c). Recruitment to this stock was very poor during the mid- and late 1960's (Fig. 7), but improved in the 1970's. The 1973 and 1976 year-classes were estimated to be the strongest observed since 1964 although they were still smaller than the 1954-72 mean size. Projections indicate that the total stock biomass available at the beginning of 1978 was slightly less than in 1977, but spawning stock biomass (ages 2 and older) increased approximately 10 percent from 1977 to 1978 (Fig. 7). The catch of about 6,200 tons in 1978 was estimated to result in an increase of 5-10 percent in spawning stock biomass from 1978 to 1979. These estimates, as well as those for the other two stocks, are based on virtual population analysis (Almeida and Anderson (1979a,b,c) provide greater detail of the assessment analyses). The changes in biomass, as indicated, are more valid in a relative rather than absolute sense due to the imprecision of the data and parameters utilized in the analyses.

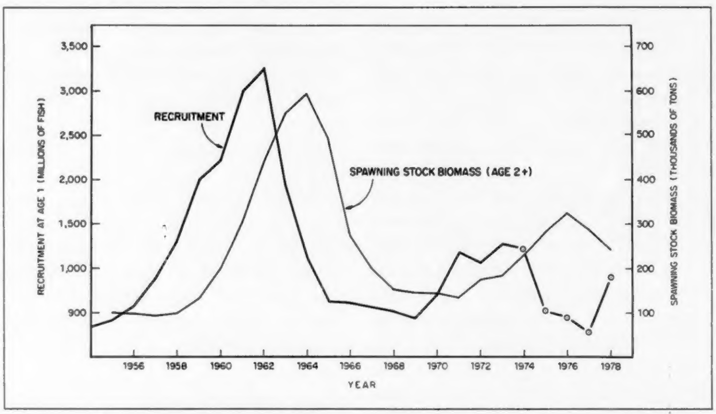



Figure 8.—Georges Bank silver hake spawning stock biomass (ages 2 and older) in 1955-78 and abundance at age 1 of the 1954-77 year classes. Open circles indicate estimated year-class sizes (Almeida and Anderson, 1979a).

### Georges Bank

Total estimated stock biomass (ages 1 and older) increased from about 110,000 tons in 1955 (Fig. 5) to a high of nearly 800,000 tons in 1963 and then declined to about 168,000 tons in 1970 (Almeida and Anderson, 1979a). Total biomass increased to approximately 332,000 tons in 1975 but then declined to an estimated 254,000 tons at the beginning of 1978. As with the Gulf of Maine stock, recruitment was very poor during the mid- and late 1960's (Fig. 8), but improved in the early 1970's. The 1975, 1976, and 1977 year classes were estimated to be poor. Projections indicate that the spawning stock biomass underwent a 10 percent de-

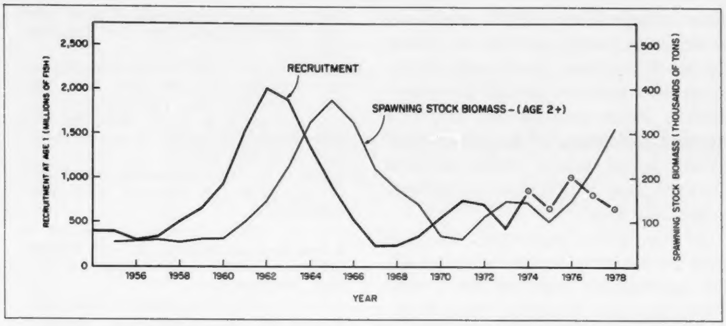



Figure 9. — Southern New England - Middle Atlantic silver hake spawning stock biomass (ages 2 and older) in 1955-78 and abundance at age 1 of the 1954-77 year classes. Open circles indicate estimated year-class sizes (Almeida and Anderson, 1979b).

crease from around 242,000 tons in 1977 to 218,000 tons in 1978. Given a 1978 catch of 10,000 tons, the resultant spawning stock biomass in 1979 will decline by about 5 percent from 1978 if the 1978 year class is assumed to be of median strength.

#### Southern New England-Middle Atlantic

Total estimated stock biomass (ages 1 and older) increased from an average of about 76,000 tons during 1955-59 to a high of close to 455,000 tons in 1965 (Fig. 6) and decreased to around 83,000 tons in 1970 (Almeida and Anderson, 1979b). Biomass increased to about 213,000 tons in 1973, decreased to an average of 189,000 tons during 1974-76, and then increased to an estimated 390,000 tons at the beginning of 1978. The 1974, 1976, and 1977 year classes were estimated to be above average (Fig. 9) with the 1976 year class estimated to be the strongest since 1964. Projections indicate that spawning stock biomass increased about 40 percent from around 201,000 tons in 1977 to approximately 286,000 tons in 1978, with the 1978 level being the highest since 1966. The 1978 catch of 26,900 tons was estimated to result in about a 20 percent increase in spawning biomass from 1978 to 1979.

### Implications of an Expanded U.S. Fishery

In an effort to promote maximum utilization of the resource and relieve some of the excessive fishing pressure presently being exerted on Atlantic cod, *Gadus morhua;* haddock, *Melanogrammus aeglefinus;* and yellowtail flounder, *Limanda ferruginea,* in New England waters, the U.S. fishing industry has been encouraged to catch and market alternate species. At the present time, the silver hake stocks constitute one of the largest and most available alternative resources. The Georges Bank stock, and particularly the southern New England-Middle Atlantic stock, are high in abundance, and current U.S. landings are considerably below the amounts reserved for U.S. fishermen. The estimated surplus stock allocated to U.S. fishermen in 1978 was about six times greater than the 1977 landings. U.S. landings of silver hake were much higher 10-15 years ago than presently due to greater market demand (e.g., reduction, mink food, and human food).

Although the Gulf of Maine stock has been slowly rebuilding since 1971, further growth is needed before the biomass reaches the level it held in the 1950's and early 1960's. Consequently, there is not the potential for increased landings from that stock beyond the 1975-77 level (about 9,000 tons) if the management strategy is to continue rebuilding the stock. The Georges Bank and southern New England-Middle Atlantic stocks, however, both offer substantial potential. Fish are not only available in inshore waters and on shoal portions of Georges Bank during the warm months, but are also available farther offshore along the edge of the continental shelf during the cold months.

There are various factors which must be considered in promoting an expansion of the U.S. silver hake fishery. Expanded effort in the offshore fishery may result in conflict with lobster pots fished throughout portions of the offshore area. Conflict with lobster pots has also existed with the DWF trawl fishery. An offshore fishery for silver hake may involve by-catch of species such as mackerel, *Scomber scombrus;* herring, *Clupea harengus harengus;* squids *Loligo pealei* and *Illex illecebrosus;* scup, *Stenotomus chrysops;* assorted flounder species, and others. The current inshore fishery also entails by-catch of species such as cod, haddock, flounder, and others, which may be greater than in the offshore fishery. The by-catch problem will require consideration in the future management of the silver hake fishery and may ultimately be solved through a multi-species approach to management.

An intensive winter-spring fishery for silver hake in offshore waters where fish concentrate during overwintering may affect availability of fish later for the inshore fishery. This may be particularly the case in the southern New England-Middle Atlantic stock. U.S. fishermen argued successfully in the late 1960's that the U.S.S.R. fishery in fact caused such a problem, and as a result a hake management area was established by ICNAF in southern New England waters during 1970-74, which prohibited fishing for hake during January-March in 1970-72 and during April in 1973-74. There is an important recreational fishery for silver hake in the New York Bight between October and June, and it is important to this fishery that fish be highly available. An

expansion in the commercial fishery in that area may reduce availability to the recreational fishery.

The U.S. silver hake trawl fishery does not have a minimum codend mesh size regulation although the DWF hake fishery has a 60-mm stretched mesh regulation. Significant expansion of the U.S. fishery in the absence of a minimum mesh size regulation may increase mortality on undersized silver hake, particularly in areas where prerecruits are highly abundant.

An expanded silver hake fishery may not necessarily relieve pressure on the Atlantic cod, haddock, and yellowtail flounder stocks in all areas. The greatest potential for expansion is in the southern New England-Middle Atlantic stock. However, this area represents the southern extent of the range for cod and haddock, and catches of these two species are less there than in the Georges Bank and Gulf of Maine areas. In the Gulf of Maine, where there is perhaps the greatest need for alternate species to cod and haddock, the silver hake stock has not yet recovered to levels capable of supporting an expanded fishery.

It was suggested earlier that silver hake in the Gulf of Maine and on the northern part of Georges Bank may belong to the same stock but that scientific evidence is presently not sufficient to either verify or disprove this theory. If these areas were combined for management, it could be harmful to the inshore Gulf of Maine resource if the allowable harvest for the combined areas were taken solely or predominantly from inshore waters. Until conclusive evidence becomes available to define the stock structure, traditional fishing areas and patterns should be maintained, which implies that any immediate expansion of the silver hake fishery in the Gulf of Maine-northern Georges Bank area should be confined to the latter area.

In conclusion, assessment analyses indicate that the silver hake resource off the northeastern coast of the United States has been rebuilding since 1970. The current low level of landings compared with the estimated available surplus stock indicates the potential for a major expansion of the U.S. silver hake fishery. Such an expansion, however, would probably impact on other species and fisheries but could be accomplished through a rational multispecies management regime.

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# Handling Whiting Aboard Fishing Vessels

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## Introduction

The same fundamental principles for handling fresh fish in general aboard fishing vessels apply to whiting. Therefore, this article will review the factors which influence the quality of fish aboard fishing boats and will offer recommendations for optimizing quality. Where specific information relative to whiting is available, it will be stressed. It is realized, however, that the fisherman often works under adverse conditions; in this circumstance, some of the recommended practices might be difficult to carry out.

## General Considerations

Spoilage of fish commences the moment they are taken out of the water. The rate of subsequent deterioration is affected by certain intrinsic factors such as species, size, season, fishing grounds, etc. and by extrinsic factors, such as handling practices, which are subject to human control. Spoilage of fish during storage at temperatures above freezing is the composite result of three different activities: 1) Bacterial decomposition; 2) autolytic enzyme action, either from tissue or digestive enzymes or from certain feed that may be in the gut, leading to torn bellies and softening of the flesh; and 3) from oxidation of lipid material, resulting in rancidity. In lean fish which have been gutted, spoilage invariably results from bacterial action; whereas, in fatty fish, loss of quality due to oxidative rancidity may precede bacterial spoilage. Rancidity does not seem to play an important role in the spoilage of chilled whiting.

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## Factors Affecting Quality

### Washing

It is extremely important that the fish be iced as soon as possible after emptying the nets. However, prior to icing, the fish should be washed to remove mud, blood, and intestinal contents which may have been expelled as a result of the intense pressure developing when the nets are hoisted out of the water. Unless the washing operation is executed thoroughly and efficiently, the entire effort can be a waste of time and resources (Castell et al., 1956; MacCallum et al., 1963). If the washing is to be conducted manually with a hose, a copious amount of water under pressure should be used. Mechanical cylindrical washing machines are efficient and also offer the advantage of being geared to a conveyor device for transporting the fish to the hold for stowage with a minimum of handling and in a regulated flow, thus allowing for proper icing (Waterman, 1965).

### Bleeding

Although not feasible with large catches of small fish, bleeding prior to evisceration is a desirable practice in that it results in a lighter colored flesh and also removes heme compounds which promote oxidative rancidity. Bleeding is usually accomplished by cutting the throat, and it is recommended that the fish be allowed to bleed for about 15 minutes before washing.

### Gutting

Because of the large number of fish usually captured in an average whiting tow, evisceration would be labor intensive and is not carried out except possibly (depending on the economics) with the large fish referred to in the trade as "king whiting." If the fish are to be gutted, it is imperative that this operation be done properly. Rupture of the intestines could contaminate the gut cavity with intestinal contents and accelerate spoilage. Failure to remove the last few inches of intestine which remained attached to the vent resulted in obnoxious odors in that section of the fillet, and extension of the knife cut beyond the vent into the muscle caused a more rapid deterioration in that area of the fillet removed from the fish (Castell et al., 1956). It is often the practice to remove gills from large fish, particularly in the summertime; this action retarded the development of off-odors and spoilage when the fish were examined as whole gutted fish, it had no effect on the quality of fillets cut from these fish (Castell and Greenough, 1956). The benefit to be gained from washing fish after gutting appears to be related to the efficiency with which the evisceration is performed. Nevertheless, it was observed that washing eviscerated fish in chlorinated (50-60 ppm) seawater under pressure rinsed the blood and slime off the fish more effectively than did plain seawater (Linda and Slavin, 1960). The odor or color of the flesh was not affected.

### Handling

Whiting is a soft textured fish particularly susceptible to bruising. Consequently, rough handling aboard the

vessel should be avoided. Bruising of freshly caught live fish usually results in discoloration of the flesh. Although this effect is not apparent with freshly caught dead fish, it has been shown that bruised fish do not keep as well as undamaged fish (Castell et al., 1956).

### Effect of Rigor Mortis

Rigor mortis in muscle is characterized by the formation of lactic acid from glycogen with a subsequent lowering of pH and, also, a stiffening of the muscle due to contraction (Amlacher, 1961). Bacterial growth on fish does not commence until rigor mortis has been resolved. Thus, to optimize quality, it is necessary that the total time to resolution of rigor be maximized.

Lowering the body temperature close to freezing delays the onset of rigor. The duration of rigor is also a function of body temperature and the glycogen content at death. A high glycogen content and a low temperature above freezing both serve to prolong rigor. As an example of temperature effect, the duration of rigor for trawl-caught whiting was 20 hours for storage at 0°C (32°F) compared with 11 hours for storage at 12°C (53.6°F) (Cutting, 1939). Rigor mortis is of longer duration when the fish has exerted less muscular activity prior to death resulting in a higher glycogen content (Amano et al., 1953). Bramsnaes (1965) cited results of several studies which demonstated that rigor mortis developed earlier and disappeared sooner in trawl-caught fish compared with fish caught with hand lines. This was attributed to struggling, crushing, and anoxemia in the trawl-caught fish. It is also believed that the shorter the trawler haul is, the better the fish will keep. In any given catch of trawl-caught fish, some of the fish may still be alive when the nets are hoisted on deck; and, thus, there may be a variation among the fish in the amount or degree of struggle expended prior to death. This could account in part for the variability in keeping quality within the same catch of fish. The onset and duration of rigor vary with different species. In general, flatfish exhibit a more extensive rigor than round fish (Reay, 1949). It is generally acknowledged that whiting do not have as long a chilled storage life compared with other gadoids (Reay and Shewan, 1949; Mendelsohn and Peters, 1962). This may be related to the fact that resolution of rigor in whiting has been found to be much quicker than in other gadoids (Cutting, 1939).

### Effect of Temperature

The most important single factor controlling spoilage of fresh fish is storage temperature. Temperature regulates the onset of rigor mortis and also the lag period and growth rate of spoilage microorganisms.

The flesh of freshly caught fish is sterile (Procter and Nickerson, 1935). The microorganisms that are present are located on the skin in the slime layer, gills, and gut. Initially, the numbers on the skin are essentially low averaging about $10^3$ to $10^5$ per square centimeter (Georgala, 1958; Spencer, 1961), but through mishandling and contamination from the deck and in the pens, the bacterial load can increase quite rapidly. The types of bacteria that eventually induce spoilage in iced North Atlantic (temperate waters) fish are termed psychrophilic or psychrotrophic, which signifies a tolerance for low temperatures. They constitute the natural microflora of newly caught fish and may also be picked up adventitiously during subsequent handling (Shaw and Shewan, 1968; Shewan, 1961). These bacteria are capable of growing at temperatures slightly below freezing; however, they grow most rapidly in the temperature range of 20-25°C (68-77°F) (Hess, 1950). Although the relationship between storage temperature and spoilage rates of fish has been shown to be approximately linear within certain temperature limits (Spencer and Baines, 1964; Ronsivalli and Licciardello, 1975) as the temperature is lowered and approaches 0°C (32°F), the growth rate of fish spoilage bacteria is drastically retarded. It has been shown that a reduction in storage temperature of 3 degrees at just above freezing adds proportionately more to the keeping time of fish than a similar reduction at a higher temperature (Castell and MacCallum, 1950). Consequently, it behooves the fisherman to rapidly lower and maintain the temperature of the fish to as close to freezing as is possible in order to obtain maximum shelf life. This can be accomplished by the judicious use of various cooling media.

## Chilling

### *Fresh-water Ice*

The amount of ice required for a trip will depend on the season, length of trip, size of the catch, and insulation of the boat. For a 5-day summer trip in North Atlantic waters, it has been calculated that 0.113 kg (0.25 pound) of ice is adequate for cooling 0.454 kg (1 pound) of fish from 12.8 to 0°C (55-32°F), and an additional 0.182 kg (0.4 pound) is required to maintain the fish away from the pen surfaces, to cool the hold, and remove heat leaking into the hold (MacCallum, 1955b).

From these requirements, a ratio of 0.454 kg (1 pound) of ice to 0.681 kg (1.5 pounds) of fish was recommended to ensure landing high quality fish. In practice, in northern waters in uninsulated holds of wooden vessels, a ratio of 1:2 (ice to fish) is commonly used (Dassow, 1963). In a survey of handling practices aboard whiting vessels in the New England region, it was found that an average of 0.454 kg (1 pound) ice was used for 1.73 kg (3.8 pounds) fish; however, the range was 1:1.8 to 1:8.2 (Peters et al., 1964).

Ice of small particle size such as produced in a flake ice machine or finely crushed block ice is recommended since it permits more intimate contact with the fish for more efficient cooling and, also, is less damaging to the flesh in comparison with large chucks of ice (Waterman, 1971). A mechanical refrigerating system installed in the hold can lessen the requirement for the amount of ice to be carried; however, air temperature at the pens should not be allowed to go below freezing since one of the benefits of ice, in addition to cooling and providing aerobic conditions around the fish, is that the melt water washes away blood and bacteria laden slime as it slowly trickles down through the fish.

Storage of ice in a refrigerated compartment is desirable, however, because crushed ice held at temperatures above freezing tends to fuse into a solid mass which has to be broken up manually or put through a crusher prior to use.

The precise method of icing varies with the construction of the hold and layout of the pen for a particular vessel. A satisfactory method for most vessels employing bulk storage is as follows (Anonymous, 1959): Cover the floor of the pen with a layer of ice 20-30 cm (8-12 inches) deep. A similar amount should be placed along the sides of the pen. A layer of fish not exceeding 15 cm (6 inches) deep should then be placed on the ice and covered with a 20 cm (8 inches) layer of ice. Fish and ice should be mixed together.

Successive layers of ice and fish should then be built up in the same manner until an overall depth of 1.2 m (4 feet) is reached, at which point shelf boards are inserted and the stowage process repeated. Gutted fish should be placed with the belly cavity down, and in the case of large fish, the cavity should be filled with ice.

For proper cooling, it is important that intimate contact be made with fish and ice. It was observed in a situation in which fish were piled in layers 38-46 cm (15-18 inches) deep and interspersed with thinner layers of ice, that the fish at the center of these layers often required 24-36 hours to cool down to near the temperature of melting ice (Castell et al., 1956).

In a survey of whiting fishing vessels, it was observed that the fish were usually bulk stored in pens with no shelving (Peters et al., 1964). This practice should be condemned. At the depth of about 3 m (10 feet) found in the unshelved pens of these boats, the pressure on fish at the bottom was calculated to be 780 pounds per square foot (3,900 kg/m$^2$) (Punchochar and Pottinger, 1947; Peters et al., 1964). These bottom fish are not only poorer in texture compared with the top of the catch but may also have lost 10-12 percent of their original weight (Ellison, 1934; Castell et al., 1956). This situation is exacerbated when the vessel encounters storming seas, and the penned fish are subjected to a physical pounding. Another precaution which must be observed is that species of dissimilar keeping quality should not be stowed together. Thus, for instance, whiting, cod, and plaice having storage lives of approximately 9, 12, and 18 days respectively should be stored separately on long trips (Bramsnaes, 1965).

*Cleanliness in the Pens*

Optimal quality of fish aboard a fishing vessel is obtained in part by maintaining as low a bacterial load on the fish as possible through sanitary handling practices and by preventing multiplication of the bacteria present by means of adequate cooling. It has been demonstrated that heavy bacterial loads imparted to fish through improper handling aboard fishing boats resulted in shorter shelf life (Castell et al., 1956; Huss et al., 1974).

Although the ice used for cooling the fish has often been found to be a source of bacterial contamination, a prime source of contamination is from slime-ridden boards (Castell et al., 1956; Georgala, 1957; Reay and Shewan, 1960). The bacterial flora of these pen boards is comprised predominately of the psychrophilic types which are ultimately responsible for the typical spoilage of fresh fish.

When fish are stored in pens and firmly pressed against the pen boards, anaerobic conditions prevail at the interface, and these bacteria (predominately pseudomonas species) under these circumstances produce a type of spoilage referred to as "bilgy" fish because it is suggestive of bilge water (McLean and Castell, 1956).

Methods of prevention include cleanliness in the pens and sufficient ice around the fish to maintain aerobic conditions. A thorough cleansing and hosing of the hold and pens after each trip, particularly with a sanitizing agent such as hypochlorite or a quaternary ammonium compound, is strongly recommended (Cutting, 1953; Linda and Slavin, 1960). The use of harbor water which is usually grossly contaminated is to be avoided.

Application of an approved detergent either with a pressure sprayer or by hand scrubbing will greatly facilitate the removal of slime and other organic matter and enhance the effectiveness of the sanitizing agent. With unpainted, porous, slime soaked wooden pen boards, a significant reduction in bacterial count is not usually effected by washing and sanitizing (MacCallum, 1955a).

Resin impregnated wood and particularly metal lined or metal such as aluminum alloy when used for pen construction are most effectively cleaned by washing and sanitizing. Lining the pens with a disposable plastic sheeting such as 6 mil polyethylene is a simple but effective method of protecting fish from pen boards (Tretsven, 1969). The use of paint, although advocated for many years, is now considered of dubious value since moisture can enter into the wood through cuts and abrasions in the coating and promote anaerobic bacterial growth and rotting of the wood. Treatment of the pen boards with a wood preservative such as copper-8-quinolinolate was recommended to prevent wood rot (Tretsven, 1969).

*Boxing at Sea*

Some of the problems encountered in bulked pen storage can be eliminated by boxing in ice at sea (Waterman, 1964). The crushing effect of excessive pressure in particular is reduced; and, in addition, there is a greater opportunity for the catch to be carefully and speedily handled during stowage and after discharge from the boat. There may be a slightly greater space requirement aboard the vessel for boxed fish. As with pen stowage, the fish should not be packed in direct contact with the surfaces of the box, otherwide the "bilgy" type of spoilage may result.

*Seawater Ice*

Seawater ice has a slightly lower melting point than freshwater ice, and, thus, offers the advantage of cooling fish at a slightly faster rate and to a lower temperature (Peters and Slavin, 1958). There is a disadvantage in that it melts faster than freshwater ice and has to be replenished which necessitates

carrying a greater initial load aboard the vessel if obtained from shore based plants. In addition, it cannot be transported to the fishing grounds without being cooled to subfreezing temperatures, or else the concentrated brine contained in the ice would quickly drain off (Eddie, 1961). It is believed that the real advantage of seawater ice may reside in its ability to be easily manufactured at sea where freshwater ice is not available (Slavin, 1965).

*Refrigerated Seawater*

The benefits of using refrigerated seawater (RSW) or refrigerated brine for storing fresh fish on board a fishing vessel have been stated as: 1) Greater speed of cooling, 2) less textural damage due to reduced pressure upon the fish, 3) lower holding temperature, 4) greater economy in handling the fish due to time and labor saved, and 5) longer effective storage life of the fish (Stern and Dassow, 1958). The real advantage of RSW compared with freshwater ice appears to be that the brine temperature can be maintained at about −1°C (30°F), which is just above the freezing point of fish.

As previously stated, the rate of bacterial growth on fish is depressed considerably by a slight decrease in temperature in the region of 0°C. Storage of whiting in RSW at −1°C (30°F) extended the storage life about 3 days compared with ice storage. Whereas the RSW held fish did not lose any soluble protein (compared with a slight loss for iced fish), there was a significant increase in sodium chloride content which would restrict its use in low sodium diets (Cohen and Peters, 1963a, b). The frozen storage life at −17.8°C (0°F) was comparable for whiting stored for 2 days in either RSW or ice. Beyond a 2-day holding period, the RSW fish had the longer frozen storage life (Peters et al., 1963). Thus, for trips of short duration, the full potential benefit of RSW storage of whiting may not be realized.

In another independent study, summer-caught whole whiting kept on ice for 5 days were considered unmarketable because of very soft texture while fish held in RSW still maintained a firm texture after 5-6 days (Hiltz et al., 1976). The results of this study also confirmed the previous finding that better frozen storage characteristics were obtained with fillets from RSW fish compared with ice fish. Enzymatic production of formaldehyde (and dimethylamine), which is mainly responsible for the development of toughness in the hakes during frozen storage, was less pronounced in the RSW fish.

Although it is now generally regarded that the storage life of whole fish is longer in RSW than in ice, the shelf life is limited by the uptake of water and salt, particularly with the lean fish and with some species by the development of oxidative rancidity. The salt concentration of whiting fillets cut from whole fish stored 5-6 days in RSW was reported to be 0.82-0.85 percent (Hiltz et al., 1976). This salt concentration was not considered objectionable but rather was said to enhance the acceptability of the bland flavored whiting.

A problem common with all fish species held in RSW is the eventual growth of spoilage bacteria in the brine with the production of foul odors which can be imparted to the fish (Roach et al., 1961). The bacterial growth can be suppressed through the addition of antibiotics or carbon dioxide to the seawater (Steiner and Tarr, 1955; Barnett et al., 1971) or by irradiating the seawater with ultraviolet or gamma rays (Peters et al., 1965; Nickerson and Licciardello, 1965). Of these various treatments the use of $CO_2$ would be the preferred one, although it should be pointed out that with prolonged storage in carbonated RSW, textural deterioration may occur.

*Chilled Seawater*

For the small boat fisherman, the benefits of RSW storage can be attained without the requirement for a mechanical refrigeration system through the use of chilled seawater (CSW) or slush ice. This entails stowage of fish, ice, and seawater in tanks in the ratio of 3:1:0.5-1. The exact proportions for maintaining temperatures slightly below freezing (0°C) depend on temperature of the fish and seawater and duration of the trip. Successful results have been reported with herring and mackerel (Lemon and Regier, 1976; Hume and Baker, 1977). With this system, it is important that ice and seawater be mixed together just prior to loading with fish and that efficient circulation is maintained.

## Recommendations

Following a comprehensive study of the whiting fishing industry for the purpose of improving the quality of landed whiting, the following recommendations were made (Peters et al., 1964): 1) Wash the fish prior to storage in the hold, 2) shelve fish pens at no greater than 4-foot intervals (or box at sea), 3) use 1 pound of ice to each 1.5 pounds of fish (for short trips less ice might suffice), 4) reduce dockside layovers to less than 14 hours, and 5) consider use of refrigerated seawater aboard vessels (hold fish no more than 4 days in ice or 7 days in RSW).

To this list of recommendations, the following should be added: 6) Careful and rapid handling of the fish on deck to reduce their exposure to sunshine and high temperature, 7) prevention of fish from coming in direct contact with pen boards, and 8) addition of a sanitizing agent to the wash water.

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# Silver Hake—A Prospectus

PAUL M. EARL

## Introduction

Silver hake, *Merluccius bilinearis*, is commonly referred to as "whiting" along the eastern seaboard of the United States. Geographically it ranges from North Carolina to Newfoundland. Whiting prefer somewhat warmer water than other gadoid species and can be found over a variety of bottom types, except rocky bottoms, from the tide line to 400 fathoms. Whiting seldom grow larger than 60 cm with an average length of approximately 35 cm (Bigelow and Schroeder, 1953).

Historically whiting have played an important role in the commercial fisheries of the Atlantic coast. Landings peaked during the late 1950's at about 60,000 t (Fig. 1) (Fritz, 1963). Since then, however, landings have declined steadily averaging approximately 19,500 t during the last 5-year period (1974-78). The New England catch represents over 70 percent of the total U.S. landings.

During the period 1962-76, the Atlantic whiting resource was harvested intensely by several foreign nations (Combs, 1977). In 1965, the U.S.S.R. harvested nearly 300,000 t from the Georges Bank area. From 1966 to 1976, foreign landings averaged approximately 100,000 t annually. After implementation of the Fishery Conservation and Management Act (FCMA) in 1977, foreign fleets were allocated quotas to harvest whiting on the basis that stocks were in reasonably good shape and U.S. capacity was less than estimated optimum yield. Foreign allocations for 1977, 1978, and 1979 were 73,720 t, 50,400 t, and 52,200 t, respectively.[1]

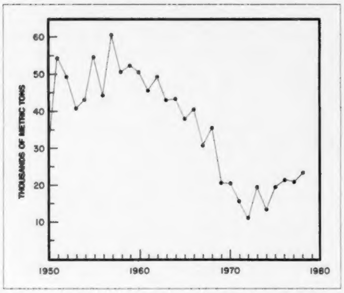


Figure 1.—Annual Atlantic coast silver hake landings, 1950-78.

Whiting has been an important food fish since the 1920's with principal markets in the Midwest and South (Fritz, 1962). It was processed into a variety of market forms, headed and gutted or dressed (H&G); "butterfly" fillets; and the larger fish ("king" whiting) sold in regular fillet form. Large quantities were also used for industrial products such as fish meal and other types of animal food (O'Brien, 1962).

Since the early 1960's, consumer demand has declined, particularly for butterfly fillets. The majority of the fish landed today are processed into H&G packs. Processors begin packing H&G whiting about May of each year and continue until October or November. Most of the production for a particular year is sold by the beginning of the Lenten Season the following year. Recently, however, the domestically produced product has been competing with lower priced imported packs and some local processors have experienced difficulty in reducing inventories.

Secondary processors (producers of fish sticks and portions) experienced a record-setting year in 1978 for portion production (U.S. Department of Commerce, 1979). Imports of frozen fish blocks also established a new record, with cod, pollock, and haddock being the principal species used for the production of sticks and portions. Worldwide shortages of these three species have caused processors to look for alternative species. Whiting imports seem to have increased rapidly from practically nothing in 1974 to almost 18,200 t in 1978 (Table 1). Whiting blocks appear to be established firmly in the U.S. market.

*ABSTRACT–The silver hake (whiting) resource off the U.S. east coast is currently being underharvested. Limited markets for traditional product forms and lack of adequate processing technology to produce new product forms have curtailed full utilization of the resource. This paper describes recent trials using commercially available equipment and discusses the economic feasibility of processing small whiting into fish blocks.*

[1]Total Allowable Level of Foreign Fishing (TALFF), New England Regional Fishery Management Council.

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Considering the apparent strength of the whiting resource and the apparent acceptance of whiting in the marketplace, the New England Fisheries Development Program (NEFDP) set out to determine what impediments exist before total utilization of the resource could be realized by U.S. fishermen.

In 1977, the NEFDP Task Force contracted with Earl R. Combs, Inc.[2] (ERC, Inc), Economic Consultants, to analyze the whiting fishery and recommend a course of action that could lead toward complete utilization of the resource by U.S. industry. In their analysis, ERC, Inc., suggested that the fresh whiting market was limited and the markets for H&G product were close to being saturated at the current production levels. The only real prospect for a significant expansion of the fishery was in the area of fillet block production. However, mechanized processing facilities capable of processing large quantities of small fish would be essential.[3]

ERC, Inc., arranged to process a small quantity (90 kg) of whiting using commercially available machines which were on display at Fish Expo in Seattle, Wash., in October 1977. These machines, manufactured by the ARENCO Corporation, Gotenburg, Sweden, were designed to process small cod, haddock, pollock, and European whiting 25-40 cm in length. The results indicated that mechanical processing was technically possible but more extensive commercial-scale trials would be needed to demonstrate the practical application and economic feasibility of such a venture.

## Scope of the Project

The ARENCO Corporation offered to make available on loan to the NEFDP one SFA-4 filleting skinning machine (Fig. 2) and one CIV heading machine (Fig. 3) for use by the NEFDP for a period of time necessary to evaluate the effectiveness of these machines for processing whiting.

It was agreed that a demonstration would be more meaningful if the machinery was located in a processing plant and operated by plant personnel. Arrangements were made with a Gloucester processor to install the machinery and provide labor to process an amount of round whiting necessary to produce 2,275 kg of fillet blocks.

The machines were tested for performance on firm as well as soft fleshed fish to determine differences in yield. It was also necessary to determine the capability of the SFA-4 to deep skin or defat whiting fillets (Fig. 4) to see what effect this has on shelf life of the finished blocks in frozen storage. Studies were also initiated to test the effectiveness of different packaging techniques and chemical additives on shelf life. Samples were examined at each stage of processing for bacterial buildup. Complete records for each day's run were kept for an economic evaluation. The overall quality of the blocks was determined by standard lot inspection procedures in accordance with U.S. Department of Commerce (USDC) standards throughout the production period. Finished blocks were to be distributed to major secondary processors for evaluation.

## Results

Approximately 14,000 kg of round whiting were processed during an 11-day period. The inplant activities were supervised by a consultant experienced in block making and production

**Table 1.—Imports of fish blocks of selected species.**

| | Imports (1,000 t) | | | |
|---|---|---|---|---|
| Year | Cod | Pollock | Haddock | Whiting |
| 1975 | 73.0 | 34 | 16.6 | 3.9 |
| 1976 | 81.9 | 43.2 | 12.9 | 9.4 |
| 1977 | 93.1 | 37.7 | 14.0 | 10.2 |
| 1978 | 93.0 | 36.9 | 12.3 | 18.2 |

Source: NMFS statistics.

**Table 2.—Cost estimates for producing whiting fillet blocks.**

| Item | Cost est. |
|---|---|
| Machine cost | |
| One processing line including: | Total cost (C.I.F. processing plant |
| (1) ARENCO elevator and washer de-icer to feed CIV header | $ 7,224 |
| (1) ARENCO CIV header (125 fish/min) | 18,984 |
| (2) ARENCO SFA-4 filleting and skinning (@ $38,640 ea.) | 77,280 |
| (1) ARENCO Flexodul conveyor system | 14,400 |
| Standard "rubber-band" conveyor | 1,500 |
| Candling tables and conveyors | 3,000 |
| Subtotal | $122,388 |
| Amortization @ 10 years | 12,239/year |
| Maintenance @ 20% of machine capital costs per year | 24,477 |
| Total yearly cost of one line | $ 36,716 |
| Production cost | |
| Assuming 1,000 hours/year operation, machine costs = $36.75/hr | |
| Assuming an actual processing rate of 100 fish/minute, a 50-minute working hour, and 2 fish per pound, then 2,500 lb of round fish per hour will be processed. At an average yield of 27 percent, 675 lb per hour of fillets will be produced | |
| Total machine cost per pound of fillets | $0.054 |
| Labor cost | |
| CIV | 2 operators |
| SFA-4 | 2 operators |
| Fillet inspection | 2 operators |
| Trimming | 2 operators |
| Block packing | 2 operators |
| Floor labor | 1 operator |
| Total | 11 operators |
| Average rate including benefits is $6.50/hour/person times 11 people equals $71.50/hour | |
| Labor cost per pound of fillets | $0.106 |
| Raw material cost | |
| At 27 percent yield, 3.7 pounds of round fish will be required to produce one pound of fillets. At an ex-vessel price of $0.10 the raw material cost is $0.37/lb | |
| However, for each pound of fillets produced, 73 percent or 2.71 lb is waste. Assuming $.015/lb waste value then $0.04/lb can be deducted from the raw material cost for each pound of fillets produced | |
| Adjusted raw material cost | $0.33/lb |
| Total: machine, labor, and raw material cost | $0.490/lb |
| Total: transportation, packaging, and freezing cost | $0.080/lb |
| Total cost to produce blocks | $0.570/lb |

Source: ERC, Inc.

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[3]Earl, P.M. 1978. Preliminary results of testing commercially available equipment for processing small whiting (*Merluccius bilinearis*). Unpubl. manuscr., 6 p. Fisheries Development Services Branch, National Marine Fisheries Service, NOAA, P.O. Box 1109, Gloucester, MA 01930.

techniques. The labor force varied from four to eight people depending on the quantity of fish available for each day's production. One to two workers were required to sort and weigh fish and supply the CIV heading machine. One person operated the CIV machine and one person fed the SFA-4 filleting and skinning machine. Two to three people were required for inspection and trimming fillets and one person for block making.

Fish for each day's production came from the following sources: 1) Penned fish[4] bulk held in chilled seawater (CSW) before processing, 2) boxed fish from day boats, and 3) penned fish iced onboard, then boxed.

Most of the fish used during the trials were boxed fish less than 1 day old, landed in the afternoon and held, refrigerated, overnight, and processed the next day. For comparison purposes, day boat fish held in CSW after landing and 3-day penned fish were also processed.

The fish were received in the processing area and the internal flesh temperature taken. The fish were then sorted by size and those under 25 cm and over 40 cm were rejected. Fish 25-40 cm long were weighed prior to feeding to the heading machine. Weight of heads was recorded and headed fish were conveyed to the SFA-4 for filleting and skinning. Napes were also weighed.

The CIV heading unit worked flawlessly on fish of the proper size. Problems were encountered, however, when fish larger than 45 cm or fish improperly oriented were run through the machine.

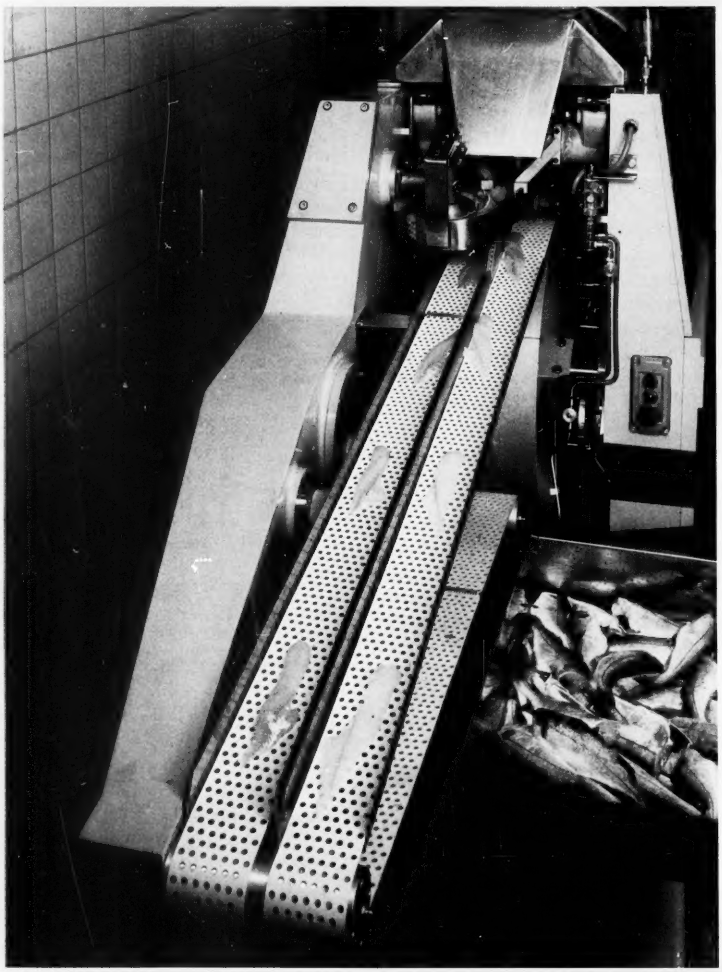
Some experience was necessary for feeding fish to the SFA-4. If fish were fed too rapidly or oriented improperly, jamming of the machine resulted. Soft fish also caused the machine to jam. Generally, if the fish were firm and the size differential between successive fish not too great, the machine performed well and down time was minimal. The amount of hand trimming necessary to remove bones or pieces of skin was also dependent on the condition of the fish. Softer fish required more hand trimming than firmer fish.

To demonstrate the importance of fish condition on yield, boxed fish were taken directly from the vessel and transferred to a CSW container at the plant. They were held in CSW overnight and processed the next day. The percentage yield of these fish was among the highest for any day's production. Heavily iced fish also produced high yields. It was evident throughout the trials that as the internal temperature of the fish increased, the yield decreased.

The skinning adjustment was very reliable and deep skinned fillets could be produced consistently without frequent readjustment. The average yield for deep skinned fillets throughout the production period was approximately 21 percent. Heads were 28 percent; napes 20 percent; skin, bones, and viscera (including roe and milt) 31 percent

[4]Penned fish refers to iced fish stored in pens in the hold of fishing vessels.

Figure 2.—The ARENCO SFA-4 filleting and skinning machine for processing small groundfish species. The machine employs an electronic computer to adjust the cuts for different fish sizes.



of the round weight. Blocks were packed using 18 pounds 14 ounces of fillets in each carton.[5]

All lots of fish inspected by USDC inspectors were of Grade A or high Grade B quality. Flavor and odor were Grade A throughout. All significant defects in the blocks could be attributed to handling problems caused by insufficient floor space and makeshift arrangements. They were not related to inadequacies of the machinery. Most grading defects stemmed from improper fill or underweights. Point deductions for extraneous material such as fins, scales, etc., would have been reduced had the line been set up properly.

Although there are no established bacterial standards for total plate count and fecal coliforms of frozen fish blocks, the blocks produced were within limits currently acceptable by the "trade." There was no bacterial buildup on the fillets or blocks throughout the day's production. Fecal coliforms and *Escherichia coli* were absent.

Of the questionnaires distributed to secondary processors by the NMFS Marketing Staff, 78 percent were returned and most were quite positive. All but one firm indicated that the overall quality was excellent and they would purchase domestically produced whiting blocks if they became available. The most common criticism concerned the small size of the fillets.

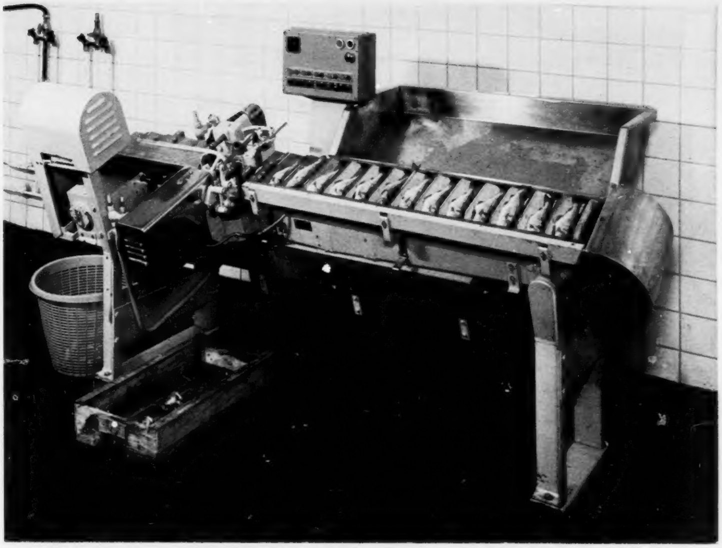


Figure 3.—The ARENCO CIV heading machine. The suit automatically adjusts for different sizes of fish for maximum yield.

Figure 4.—Deep skinned ("defatted") fillets (above) or "regular" fillets (below) could be produced with a simple adjustment on the SFA-4 filleting and skinning machine.

## Discussion

Quality of the raw material (whole fish) was the most important in the overall results during the trial of the ARENCO CIV and SFA-4 machinery. Good quality fish resulted in less jamming of the machinery, and provided the highest yield.

The machinery performed well throughout the production run and maintenance was minimal. Frequent adjustments were not necessary when size limits for the fish were adhered to. The SFA-4 produced smooth fillets without ragged edges or tearing. Cleaning of the machinery was easily accomplished. The only shortcoming of the equipment was the yield of the end product.

Close examination of the skeletal structure revealed that whiting has fewer pinbones than a cod or haddock. Consequently, more of the nape was being removed than was necessary.

[5]This amount may have been somewhat generous, depending on the time the fillets were allowed to drain before packing. Although more trials would be necessary, it appears that 18 pounds 12 ounces of fillets could still yield a consistent net weight of 18.5 pounds after freezing, if the blocks were made immediately after inspection and trimming.

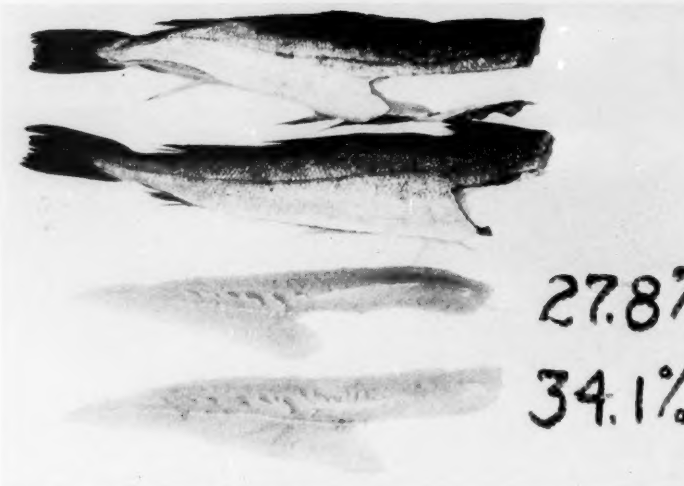



Figure 5.—Before the SFA-4 filleting and skinning machine was modified, more of the nape was being taken away than was necessary to remove the pinbones (upper fish frame and resulting fillet, 27.8 percent yield). After modification the yield was improved, in this instance, to 34.1 percent.

**Table 3.—Cost estimates for producing H&G whiting.**

| Item | Cost est. |
|---|---|
| Machine cost | |
| (1) two sided heading unit | $20,000 |
| (1) rotary washer-scaler | 10,000 |
| (1) packing-inspection table | 8,000 |
| Misc. conveyors, flumes, etc. | 6,000 |
| Subtotal | $44,000 |
| Amortization @ 10 years | 4,400/year |
| Maintenance @ 20% machine capital costs per year | 8,800/year |
| Total yearly cost of one line | $13,200/year |
| Production cost | |
| Assuming 1,000 hours/year operation, machine costs = $13.20/hour | |
| Assuming a processing rate of 12,000 lb per hour, a 50 minute working hour and a yield of 50 percent, then 5,000 lb per hour of H&G whiting will be produced. | |
| Total machine cost per pound | $0.003 |
| Labor cost | |
| Heading unit | 12 operators |
| Packing table | 12 operators |
| Weighing | 2 operators |
| Floor labor | 6 operators |
| Total | 32 operators |
| Average rate including benefits is $6.50/hour/person times 32 people equals $208.00/hour | |
| Labor cost per pound of H&G | $0.042 |
| Raw material cost | |
| At 50 percent yield, 2.0 pounds of round fish is required to produce 1 pound of finished product. At an ex-vessel price of $0.10/pound the raw material price is $0.20/lb | |
| For each pound of H&G produced, 50 percent or 1.0 pound is waste. Assuming $0.015 waste value then $0.15/lb can be deducted from the raw material cost for each pound of H&G produced | |
| Adjusted raw material cost | $0.185/lb |
| Total: machine, labor, and raw material cost | 0.227/lb |
| Total: transportation, packaging, and freezing cost | 0.080/lb |
| Total cost to produce H&G | $0.307/lb |

[1]Based on personal communication with processors.

After the production trials the machinery was moved to the NMFS Gloucester Technology Laboratory where ARENCO engineers redesigned the nape cutting arrangement. These redesigned parts were fabricated in Sweden, returned to Gloucester, and installed. A few hundred pounds of fish were processed and the results suggest that the yield was increased significantly. Before modification, a yield of 27-28 percent was achieved during a short run. This yield figure dropped to 20-21 percent during the production trials. After modification, the yield increased to 33-34 percent during a short run (Fig. 5). Although the SFA-4 was not tested in a production situation after modification, it is assumed that an increase of 6-7 percent could be achieved if another production trial was made.

## Economics

The trials described in this paper do not represent an accurate portrayal of an ideal processing operation. Lack of floor space, unfamiliarity with the equipment, and an inexperienced labor force contributed to inefficiences that were not overcome in the short period of time the equipment was available.

To demonstrate the importance of experienced labor, it was noted that direct labor costs were reduced 65 percent in a period of 7 working days. Much insight was also gained as to how a fillet block line should function to assure maximum efficiency for fish block production.

The cost analyses in Tables 2 and 3 are representative, in part, of a hypothetical processing situation for producing fillet blocks and H&G whiting. An accurate comparison would be difficult to make because of variations in plant design and equipment used. Most H&G equipment is "custom" built and tailored to an individual facility.

Plant operating costs such as indirect labor, maintenance and depreciation, taxes, etc., are not included and assumed to be the same whether blocks, H&G, or both are being produced. No adjustment has been made for variation in raw material cost. These so called "shrinkage" factors are somewhat artificial and often reflect inadequacies in processing capacity and/or excessive inventory buildup and are not always indicative of the condition of the catch. Furthermore, it is anticipated that a steady demand for fillet blocks will have a stabilizing effect on ex-vessel

**Table 4.—Wholesale price comparisons (cents per pound) of imported and domestic whiting products—1978-1979.**[1]

| Date | Blocks | | Five pound H&G | |
|---|---|---|---|---|
| | Regular | Defatted | Domestic | Imported |
| 1978 | | | | |
| Jan. | 60 | 78-82 | — | — |
| Feb. | 60 | 78-82 | — | — |
| Mar. | 57-60 | 80 | — | — |
| Apr. | 57-60 | 80 | — | — |
| May | 58-60 | 80-81 | 45 | 47-49 |
| June | 60 | 81 | 45 | 47-49 |
| July | 60 | 80-81 | 48-50 | 48-49 |
| Aug. | 60 | 8-81 | 43 | — |
| Sept. | 60 | 80 | 42-43 | — |
| Oct. | 60-62 | 80 | — | — |
| Nov. | 60-62 | 80 | — | — |
| Dec. | 60-62 | 80 | — | 39-45 |
| 1979 | | | | |
| Jan. | 59-62 | 80 | — | 41 |
| Feb. | 62 | 80-81 | 41-43 | 43 |
| Mar. | 64-65 | 82 | 40 | 30-35 |
| Apr. | 65 | 82-85 | 40-43 | 20-25 |

[1]Hall, R. L. 1979. Current whiting situation. Unpubl. rep., 3 p. Market News Branch, National Marine Fisheries Service, NOAA, Gloucester, Mass.

price, and presumably markets for raw material could be available throughout the entire year.

Table 4 suggests that during May-July 1978 demand for H&G drove the price to the $0.45-0.50 level. As landings and production increased the price turned downward and continued to slide as markets became saturated and lower priced imports came onto the market. Production ended about November. It is likely that market conditions and not availability of the resource limited production.

The 1978 H&G pack was almost 10,000,000 pounds valued at $4,400,000.[6] This amounts to an average wholesale price of $0.44 per pound or a gross profit margin of approximately $0.133 per pound.

As mentioned earlier, the market for fillet blocks appears strong with prices moving steadily upward (Table 4). The latest quoted "wholesale" price for defatted blocks was $0.85/pound. Taking an average price of $0.81/pound, a processor would gross a $0.24 per pound profit.

Although a higher initial investment would be required to set up a fillet block operation, gross profit appears higher and returns on investment would be forthcoming over 10-12 months production, not 5-7 months as is the case for H&G.

## Conclusion

Considering a resource that can be harvested more intensively, a fishing fleet that is rapidly being modernized with the capability to harvest this resource, a growing demand for high quality fish blocks, and now what appears to be adequate technology to process this resource, the silver hake fishery could expand to its full potential. Still untried and untested, however, are the economics surrounding a sustained fillet block operation.

Through the NEFDP, funds have been committed to support additional studies to determine the viability of a domestic silver hake fillet block operation. Commercial production will take place over the period of 1 year and a minimum of 45,000 kg of blocks will be produced. These blocks will be sold to secondary processors for conversion into sticks and portions. Records will be kept to determine if these domestically produced blocks can compete economically with imports.

[6]Preliminary data, NMFS Statistics Branch.

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# Utilization of Red Hake

J. M. REGENSTEIN, H. O. HULTIN, M. FEY, and S. D. KELLEHER

It has been estimated that the optimal yield of red hake, *Urophycis chuss* (also called squirrel hake, mud hake, and ling), is 32,000 metric tons (t). This is an increase from the 1978 optimal yield estimate which was 16,000 t. The international catch of this fish from Georges Bank in 1977 was 2,879 t with the U.S. commercial catch being just 96 t. Thus, there is an abundant resource of this species for development.

At present the utilization of red hake in the United States is minor with just a limited market for fresh fillets or whole fish. This species has an excellent, mild flavor with a slightly soft texture which progressively deteriorates during storage at refrigerator temperatures above freezing. In the United States, red hake is usually not marketed in any form other than fresh.

Seafood processors are constantly searching for new resources that would open new markets. One opportunity for this would be the expansion of the red hake fishery and subsequent development of a domestic fish block manufactory. A major deterrent to the development of a market for frozen red hake is the relatively short storage life of this species at commercial freezer temperatures due to the development of a tough, spongy, rubbery texture (Dyer and Hiltz, 1974).

Textural changes during frozen storage of fish can be due to several causes. Among these are denaturation of fish proteins brought on by free fatty acids released during frozen storage (Anderson and Ravesi, 1970) or by cross-linking of proteins brought about by compounds produced during oxidative breakdown of fish lipids. Red hake, however, contains a relatively low proportion of fat (approximately 0.8 percent, wet weight basis), and the rate of oxidation of this fat in frozen storage is very slow.

As is typical for the gadoid species, red hake are subject to a further type of change, i.e., the conversion of trimethylamine oxide to dimethylamine and formaldehyde which presumably occurs by an enzyme-catalyzed reaction (although it is known that under some conditions this breakdown of trimethylamine oxide can occur nonenzymatically catalyzed, e.g., by $Fe^{+2}$ (Castell, 1971)). One of the breakdown products of trimethylamine oxide, formaldehyde, is an effective cross-linking reagent capable of interacting with two molecules of protein. It is probable that such cross-linking is the principal cause of toughening of texture in frozen storage.

Trimethylamine oxide is ubiquitously found in the muscle of marine fish. The uniqueness of the red hake muscle may lie in its capability to rapidly convert its trimethylamine oxide to dimethylamine and formaldehyde. It has, in fact, been shown (Dingle et al., 1977) that the minced flesh of red hake will greatly accelerate trimethylamine oxide breakdown in a nongadoid fish. It has been reported that the dark muscle of gadoid fish contains higher concentrations of trimethylamine oxide and its breakdown products than does light muscle (Simidu, 1961). Preliminary results in the University of Massachusetts Marine Foods Laboratory indicate that the total concentration of trimethylamine oxide and its breakdown products is approximately the same in the light and dark muscle. However, under similar storage conditions there are more breakdown products formed in the dark muscle indicating that the system (presumably enzymatic) for breaking down trimethylamine oxide is more active in the red muscle. Any contamination by kidney or blood during production of the fish fillet or the minced flesh would also give an increased rate of breakdown of trimethylamine oxide.

Mincing is known to increase the rate of dimethylamine production (Hiltz et al., 1976) which is a common measure of trimethylamine oxide breakdown. It has been suggested (Dingle and Hines, 1975) that minced flesh may be washed to remove trimethylamine oxide and prevent the formation of dimethylamine and formaldehyde. Such a process may be useful in the production of surimi for export to foreign markets, particularly Japan.

With Pacific whiting it has been

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found that the exclusion of oxygen did not retard the formation of dimethylamine or formaldehyde during frozen storage (Babbitt et al., 1972). In the same report, it was also found that the type of package had little effect on the breakdown.

Several excellent studies have been carried out on the rate of conversion of trimethylamine oxide to dimethylamine and formaldehyde in frozen gadoid muscle (Babbitt et al., 1972; Castell et al., 1973; Tokunaga, 1974; Dingle et al., 1977). These studies have generally measured formation of dimethylamine and formaldehyde and a loss in extractable protein nitrogen. A recent study (Gill et al., 1979) has related chemical and physical measurements to sensory perceptions of toughness in frozen red hake muscle at −5° and −17°C over a period of 39 days. It has been estimated that the frozen storage shelf life for hake at −4°F is 22 weeks (Dyer and Hiltz, 1974). This estimate was based on a prediction of loss of protein solubility (extractable protein nitrogen).

The Marine Foods Laboratory at the University of Massachusetts Marine Station, Gloucester, currently has studies underway sponsored by the New England Fisheries Development Program to define the shelf life of frozen fillet blocks of red hake under commercial storage conditions (0°F). The study will include samples which have been saberized (deep-skinned) to remove some of the red muscle, as well as the use of 1-day old and 5-day old fish to determine the effect of postmortem age on textural development. We are also beginning research in conjunction with the National Marine Fisheries Service, Gloucester Laboratory, and Cornell University on preventing the decomposition of trimethylamine oxide to dimethylamine and formaldehyde and/or preventing further reaction of formaldehyde that is formed with protein or other components leading to large macromolecular aggregates responsible for the undesirable texture.

There are three general approaches that may be taken to achieve the goals. First, we can prevent the decomposition of trimethylamine oxide; thus, no formaldehyde would be formed. Second, we can prevent the formaldehyde which does form from interacting with those components leading to a toughening of texture. Third, reaction of formaldehyde with the protein could possibly be reversed although we feel that this last approach holds the least chance for success.

To prevent formaldehyde from being formed several approaches may be taken. One of these would be to remove the trimethylamine oxide by a washing procedure. This would be simpler in the case of minced flesh since diffusion will be a problem in the intact muscle. However, there may be ways of improving penetration of the washing solution. The enzyme converting the trimethylamine oxide to dimethylamine and formaldehyde may be inhibited or deactivated. A major approach will be to look at potential enzyme inhibitors which are also acceptable food additives for this purpose. Heating of the tissue before freezing may also be accomplished. It may be desirable to freeze a product in the raw form for a given length of time and then heat it at a later time as the product is processed into a final consumer product.

Modification of the pH of the flesh may affect either the reaction of formaldehyde with component proteins or make the enzyme-catalyzed reaction less favorable. Removal of the part of the fillet which is particularly rich in red muscle may also remove a disproportionally greater amount of enzyme, thus slowing the reaction. This may be accomplished by saberizing as discussed above or perhaps by removing a relatively small proportion of the total fillet (7 to 8 percent) near the tail portion which is particularly rich in dark muscle.

Formaldehyde may be prevented from reacting with the components which lead to toughening by: 1) removing formaldehyde by a procedure such as washing; 2) by causing it to react with components which do lead to changes in texture (these may be native components or components added to the tissue, such as compounds containing free amino groups); 3) by controlling environmental factors like pH to make conditions less favorable for the reaction to occur; 4) by converting formaldehyde into a different compound which does not cross-link protein; and 5) possibly by controlling the location of the macromolecules so that even though formaldehyde reacts with them, it cannot react with more than one thus preventing cross-bridge formation. This would be done by the rate of freezing and the control of ice crystal growth. When ice crystals are allowed to form slowly, they form in the extracellular space and compact the protein molecules making them presumably easier to cross-link. If freezing is very rapid the proteins may remain spatially separated and less likely to cross-link with other protein molecules.

A major effort will be made on the effect of preprocessing conditions on the response of the muscle tissue to changes during frozen storage. The manner of holding the fish on board the vessel, e.g., icing vs refrigerated sea-water storage, will be examined. Also it is expected that postmortem age of the red hake may be a significant factor. Since there is some softening with refrigerated storage, this may somewhat counterbalance the toughening which occurs during long-term frozen storage.

A related problem which has to be considered is how much of the reaction between the protein and formaldehyde occurs during frozen storage and how much occurs during the heat processing necessary to make the fish "table ready." Some preliminary results at the University of Massachusetts have indicated that up to 50 percent of the reaction of formaldehyde in the tissue occurs during the cooking process itself. However, this proportion is expected to vary greatly and be dependent on several factors, including the amount of formaldehyde and the exact processing procedures.

The economic value of fresh fish is significantly higher in many cases than that of frozen fish. Thus, if an underutilized fish such as red hake could be moved in the fresh form, it

may better be able to compete favorably with the higher priced species currently available to the U.S. consumer. If, in addition, the shelf-life could be extended, new markets would open up, both further inland within the United States and, of course, around the world. In the inland American market we would be introducing this low fat white-fleshed fish to an audience that is not already strongly committed to one of the more common coastal species; in the international market, we would be dealing with a consumer audience that accepts a much broader range of quality fish products.

With red hake, we are also specifically concerned with the textural changes that occur in the frozen product as were discussed elsewhere in this paper. Thus, by handling red hake in the fresh form some of these problems may be avoided. Furthermore, in those cases where the fish will be further processed, it may be more efficient in terms of labor, energy, and product quality to process red hake directly from the fresh form.

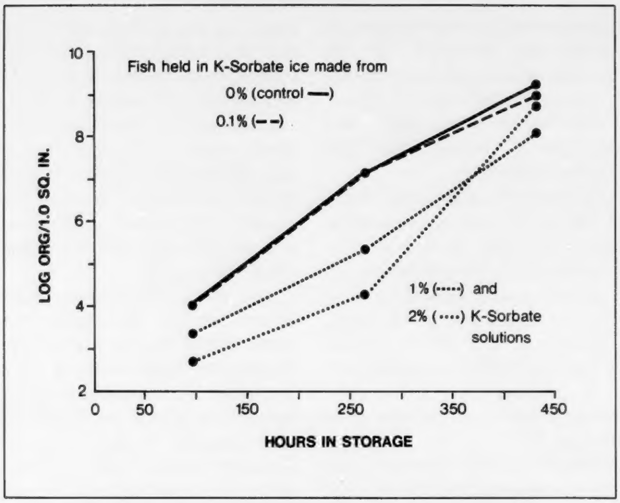



Figure 1.—Log psychrotroph count of potassium-sorbate ice treated fish with respect to time in storage. Fish were held in potassium-sorbate ice made from 0 (control), 0.1, 1, and 2% weight/volume potassium-sorbate solutions.

Preliminary results suggest that once the product is cooked, and the enzyme causing the undesirable textural change is destroyed, red hake can be stored frozen far more successfully than when it is frozen raw. Particularly in the case of minced flesh obtained either from whole fish or from bone racks after filleting, immediate heating after processing may lead to a more desirable product. It may also be helpful to be able to store red hake safely in the fresh form until it can be processed, especially when an excess has been landed. Thus there are many reasons for the interest in extending the shelf life of red hake for which a number of different approaches might be taken. At Cornell University, we are pursuing the following approaches (with Sea Grant support):

1) The addition of an antibacterial chemical to the ice may slow down the growth of surface bacteria. Since this is the major route of spoilage of fresh fish, particularly the production of trimethylamine by *Pseudomonas putrefaciens*, the inhibition of this bacterial spoilage should extend the shelf life of the fish. Clearly, the additive used must be an approved food additive.

One compound that is currently under investigation for use in a number of flesh foods is the recently reviewed compound, potassium sorbate. It is generally recognized as safe (a GRAS compound); is antimycotic, and inhibits the outgrowth of *Clostridium botulinum* spores.

The U.S. Department of Agriculture is proposing to add 0.26 percent of this compound directly to bacon to replace some of the nitrite currently being used. It has also been proposed for use in ship-board refrigerated seawater systems, particularly with salmon. With funds from the Monsanto Company[1], we have investigated the effect of potassium sorbate on a number of properties of red hake.

A short-time dip (approximately 1 minute) was relatively ineffective, even when up to a 5 percent potassium sorbate solution was used. However, it clearly inhibited the bacterial population when used in the cooling ice at 1 and 2 percent levels.

Figure 1 shows the psychrotrophic bacterial count of a surface swab which was measured at 7°C for 10 days. We also measured a number of other properties, in particular the TMA (trimethylamine) values, and various organoleptic (taste panel) properties. All the results suggested a shelf life extension of a few days.

As part of this series of experiments, we have also been examining the use of the Torry meter as a rapid way to measure quality. This meter measures changes in electrical properties of the fish from a high of 16 to a low of 0. (A previously frozen fish gives a reading of 3 or below.)

The use of such a meter, if it works, would be most beneficial with less familiar species of fish. This instrument did indicate different values for the treated and untreated samples (Fig. 2) and the values decreased as spoilage progressed. Overall sensory acceptability of cooked fish as a function of time

[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

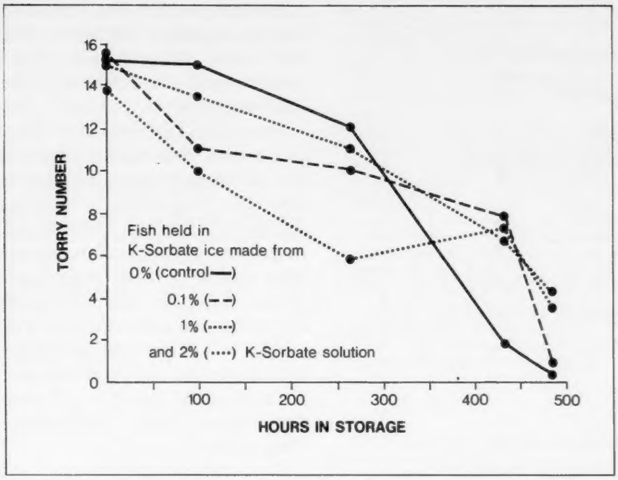
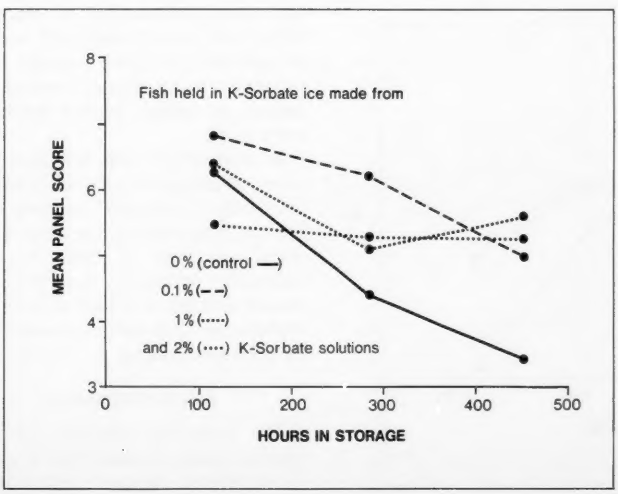



Figure 2.—Torrymeter numbers of potassium-sorbate ice treated fish with respect to time in storage. Fish were held in potassium-sorbate ice made from 0 (control), 0.1, 1, and 2% weight/volume potassium-sorbate solutions.

Figure 3.—Organoleptic evaluation: mean panel scores for overall acceptability in potassium-sorbate ice treated fish with respect to time in storage. Fish were held in potassium-sorbate ice made from 0 (control), 0.1, 1, and 2% weight/volume potassium-sorbate solutions.




on sorbate-containing ice is given in Figure 3.

Another property of the red hake which we examined was the thiobarbituric acid values (TBA). This test is used to measure the development of fat rancidity in foods. Our results suggested that very little change was occuring in the small amounts (less than 1 percent) of fat present in red hake, and we have thereafter discontinued making these measurements.

2) The second phase of the research was to examine the effects of modified atmospheres. Particularly in transportation systems, it is possible to charge a refrigerated van with various gases; however, it is generally left alone thereafter and is thus subjected to natural changes. (In controlled atmosphere systems, more elaborate controls monitor the condition of the gases and maintain a constant pre-set level.)

Modified atmospheres have been particularly effective with beef and plant commodities and thus the necessary reefer (refrigerated) vans for this type of shipping already exist. Sea-Land Services, a transoceanic container ship company, has helped to sponsor this aspect of the research.

To test a number of different atmospheres economically in a limited amount of space, we have designed a system centered around barrier bags (supplied by the Cryovac division of W. R. Grace, Inc.). Individual fish were placed in these bags without ice. A septum using silicon glue was attached to each bag so that the bags could then be inflated with various mixtures. The gases could also be extracted in small quantities at various times in order to analyze changes by gas chromatography. The system of individual bags also allowed us to remove entire samples of fish as we needed them without disturbing the other samples.

These experiments clearly showed the advantage of high (20 and 60 percent) carbon dioxide ($CO_2$) atmospheres. The addition of carbon monoxide did not have any positive effect at the 1 percent level. It should be pointed out that the fish were stored at about 0°–1°C, a temperature range that

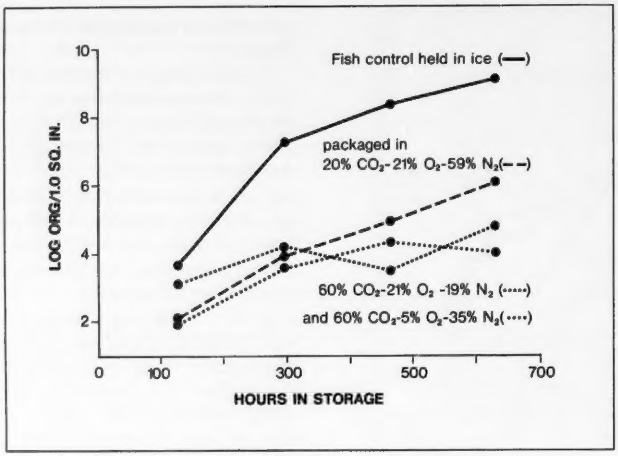
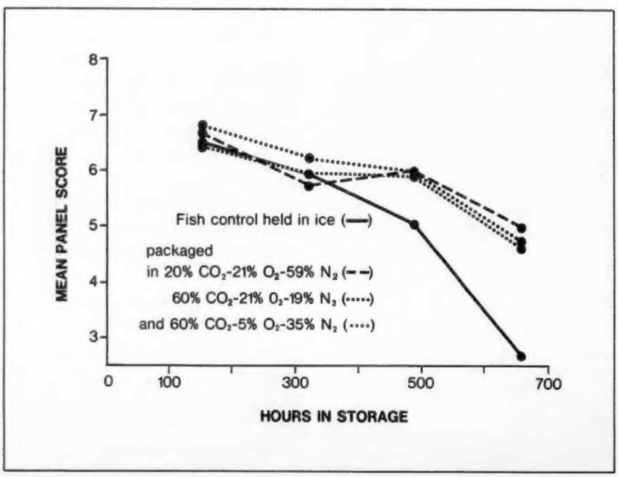



Figure 4.—Log psychrotroph plate count of fish held in ice and fish packaged in modified atmospheres with respect to time in storage. Fish were held in ice (control), packaged in 20% $CO_2$-21% $O_2$-59% $N_2$, 60% $CO_2$-21% $O_2$-19% $N_2$, and 60% $CO_2$-5% $O_2$-35% $N_2$.

Figure 5.—Organoleptic evaluation: Mean panel scores for overall acceptability of fish held in ice and fish packaged in modified atmospheres with respect to time in storage. Fish control held in ice (control), packaged in 20% $CO_2$-21% $O_2$-59% $N_2$, 60% $CO_2$-21% $O_2$-19% $N_2$, and 60% $CO_2$-5% $O_2$-35% $N_2$.




is routinely used in commercial refrigeration. Figures 4 and 5 show some of the results obtained with $CO_2$; significant shelf life extension of the red hake was obtained.

One side effect noticed in this phase of the work was that the bags retained any off-odors formed. We have called this the "bag-effect." In order to minimize this effect, which would also be present in commercial systems, we have tried to develop an air scrubbing system. We have found that bubbling the air through sulfuric acid in a closed system will lead to the formation of a trimethylamine sulfate precipitate and we are hopeful that this will decrease the internal odor, eliminating the "bag-effect."

3) In the last phase of this series of experiments, we are using larger bags in which the fish are placed in a container with a raised screened bottom which permits the melting water to drip away from the fish. This allows us to use both gas and ice (with and without potassium sorbate) to test the possible synergistic effects of the two systems. The gas scrubbing system has also been included. Using this system we cannot remove samples of fish at intermediate times; thus only the condition of the fish at the end of an arbitrary storage period can be determined.

Another area that we hope to pursue in the future is the use of a coating, such as an alginate glaze. This would protect fish against moisture loss in long-term refrigerated storage and could be used to hold the potassium sorbate. (Presumably with continuous contact, the amount of sorbate needed would be much less.)

In conjunction with Sea-Land Services, which has recently built a mobile lab within a shipable container, we hope to test some of our ideas on an actual shipment of fish. We are extremely optimistic that this and related research will lead to a further exploitation of the red hake resources of the northwest Atlantic.

## Acknowledgments

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ment Station Project No. 197, University of Massachusetts Graduate School; Monsanto Industrial Chemical Company; Sea-Land Services; and the New England Fisheries Development Program.

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# Evaluation of a Prototype Fish Cleaning Machine With Proposals for a Commercial Processing Line

J. M. MENDELSOHN and J. G. CALLAN

## Background

Heading and gutting small fish by hand is both time consuming and labor intensive, making it an expensive operation. In cases where special handling is absolutely necessary or where the products can command a high price, processing fish by hand may be economically feasible; but where the fish product has to be competitive in price with other high protein foods, or the value of the fishery product is relatively low, machine processing must be used. Not only must the economic aspect be considered but where the need to produce a headed and fully cleaned fish for further processing is important, a machine must clean the fish completely in order to be justified. This is especially evident where the fish must be headed and completely freed of viscera and belly lining, particularly when the lining is pigmented as in the case of whiting, *Merluccius bilinearis,* prior to processing in a meat/bone separator. As a solution to heading and fully cleaning whiting, a LaPine Model 22 smelt processing machine[1] was extensively modified (Mendelsohn et al., 1977).

## Preliminary Results

The modified machine (Fig. 1) was laboratory tested for processing various sizes of whiting 8-16 inches (20.3-40.6 cm) in length in test runs involving 500 pounds (225 kg) to 5,000 pounds (2,250 kg) of fish. Fish outside of this size range were culled and discarded because the processing effectiveness of the machine was not acceptable for these. Since the machine was designed to handle fish that varied in length by no more than 4 inches (10.2 cm), we adjusted the machine to handle fish in the range of 10-14 inches (25.4-35.6 cm) because this is the center of the 8- to 16-inch (20.3- to 40.6-cm) range.

The results of the laboratory tests indicated that the prototype machine had a capacity of about 3,600 fish/hour and that it could effectively head and clean the fish and remove most of the peritoneum (black belly lining) of whiting. Subsequent trial runs before industry further demonstrated the machine's potential, and only an evaluation of the machine's performance under actual commercial conditions was necessary to encourage its assimilation by industry. Coordinated by the authors, the machine was tested by a Boston processor under contract to the New England Fisheries Steering Committee (NEFSC)[2].

## Processing in Commercial Plant

Gloucester-landed whiting were brought to the Boston commercial fish processor for heading and cleaning by the modified LaPine machine. The

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[1] Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[2] NEFSC is a nonprofit educational association organized to further the interest and welfare of all those engaged in the domestic New England fishery (Anonymous, 1977).

*ABSTRACT—A prototype heading and cleaning machine for small whiting was evaluated under commercial conditions. The major finding was that the machine is sound in theory and principle but needs some of its components redesigned for high speed production. Throughput was found to be about 2,250 fish/hour (less than was expected) of which about 95 percent were cleaned well enough for further processing or to be frozen directly as a reverse-butterfly or pan-ready product.*

*From these tests, we believe that new machines could be built to handle fish from 6 to 18 inches (15.2-45.7 cm) at production rates up to 12,000 fish/hour. For increased production, three machines should be used together in a system comprising auxiliary equipment. Each machine would process a specific size range of fish with an expected total output from the three machines of about 36,000 fish/hour. The fish would be scaled, graded, oriented, conveyed, headed, and cleaned automatically with maximum recovery of edible fish flesh and with minimum waste.*

size range of the fish varied from well below 6 inches (15.2 cm) to well above 18 inches (45.7 cm). Although the machine was laboratory tested for a size range of 8-16 inches (20.3-40.6 cm), an attempt was made to head and clean whiting between 6 and 18 inches (15.2 and 45.7 cm) to determine if the enlarged size range could be acceptably accommodated.

Those fish below 6 inches (15.2 cm) and above 18 inches (45.7 cm) in length were culled and discarded. Again, as in the laboratory experiments, we adjusted the machine to handle the middle of the range 10-14 inches (25.4-35.6 cm). Once set, the controls were not changed during the runs.

This sequence was followed in a typical run using either penned[3] (5-6 day old) or day-boat (1-2 day old) whiting in the heading and gutting machine in the commercial fish processing plant:

1) Boxed iced whiting, landed in Gloucester, Mass., in the morning, were trucked to the plant in the afternoon and held overnight in a cooler at 35°F (2°C).

2) The next morning, the fish were scaled in a commercial rotary scaler.

3) The scaled fish were manually placed on the wooden cleated conveyor leading to the heading and gutting machine.

4) Every fish was headed and gutted by the machine.

5) Each fish was inspected as it left the machine. Uncleaned fish were hand-cleaned or discarded.

6) If the fish were to be sold as pan-ready (reverse-butterflied) fish, they were frozen in 10 pound boxes.

7) If the fish were to be deboned, they were transferred to a conveyor leading to the Bibun Model 18 meat/bone separator. The minced fish flesh was collected and made into 18.5-pound minced blocks and plate frozen. Frozen fish blocks are used as the raw material in the manufacture of fish sticks, portions, and other specialty items (Ryan, 1978).

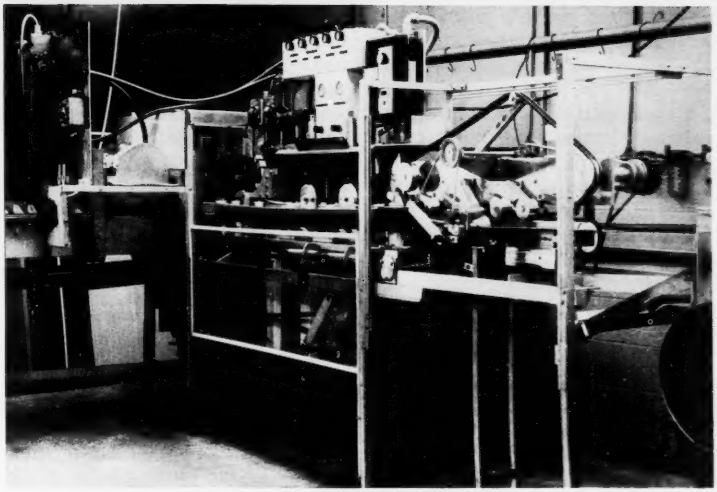

Figure 1.—Prototype fish heading and cleaning machine.

## Results and Discussion

### Operation Under Commercial Conditions

Operation of the machine under commercial conditions indicated that while the theory and the principles employed were sound and effective, the theoretical capacity of 3,600 fish/hour could not be met. The maximum processing rate reached was about 2,700 fish/hour with four people operating the machine—two people feeding the machine, one person keeping the machine running properly, and one person inspecting the fish. Even at this rate, the machine had to be stopped for about 4-5 minutes every 25 minutes for a complete wash-down to remove viscera collecting at the cleaning wheels which would otherwise impede the smooth flow of fish through the machine.

With a throughput of 45 fish/minute for 25 minutes operating time and almost 5 minutes cleanup, the machine would head and gut about 2,250 fish/hour. With the weight of the whiting averaging about one-half pound, the machine throughput was about 1,125 pounds/hour. Even if the machine throughput could be doubled by experienced operators, it would fall far short of the production rate desired by the larger processors.

Still, the economics of using the machine compare favorably with manual gutting and heading of whiting. The speed of an experienced person that hand processes whiting is about 30 fish in 9 minutes or about 200 fish (100 pounds)/hour. Even if a person could continue to handle 100 pounds/hour throughout the day, the prototype machine works over 11 times faster, with no loss in speed as might occur with a human as the day wears on. Thus while the machine might fall short of commercial processor expectations, the fact that one machine plus four workers can replace 11 skilled cutters is evidence that it still represents an economic advantage. Also, the quality of the fish remains constant in machine processing, whereas the quality of the manually processed whiting

[3]Penned whiting refers to fish from boats that have been out fishing 4 to 5 days. These whiting are 5 to 6 days old prior to processing. Day-boat whiting refers to fish from boats out fishing for only 1 day. These fish are 1 to 2 days old prior to processing.

is variable and generally poorer, especially as the workday wears on.

### Yield Recovery

Starting with whole whiting, the recovery of headless and fully cleaned reverse-butterfly whiting (pan-ready) was determined. Results from two separate runs showed that from a mixture of sizes of whole whiting (6-18 inches or 15.2-45.7 cm), yields of 46.0 percent and 46.3 percent were obtained. These yields were approximately 5 percent lower than that found under laboratory conditions. This can be explained somewhat because only whiting between 8 and 16 inches (20.3 and 40.6 cm) were used in the laboratory tests. With fish of large size ranges, the yield is appreciably decreased for the machine was set for maximum recovery in the 10- to 14-inch (25.4- to 35-cm) range.

Even if whiting are to be sold as a headless and dressed item, the 46 percent yield from the prototype machine as compared with a 50 percent yield from the conventional headless and dressed operation should be no deterrent, especially as the quality of the former is better than that of the latter.

The improved appearance of the fish with all of the viscera removed and the potential shelf life extension of the product from the prototype machine should be able to command a higher price than that of conventional headless whiting. Most whiting processed in the conventional way contain a small amount of viscera. Therefore, they cannot be labelled as headless and dressed fish but must be labelled as headless whiting.

However, in a plant under U.S. Department of Commerce inspection, the fish from the prototype machine could carry the U.S. Grade A stamp because they would easily conform to the headless, dressed whiting standard. Where the whiting are to be put through a meat/bone separator or are to be further processed, the complete removal of viscera and black belly lining is essential.

### Cleaning Efficiency

The number of fully cleaned whiting, requiring no followup hand cleaning, obtained from the machine was taken as a measure of its effectiveness under commercial conditions. Approximately 30 percent of the whiting were found to fit this category. About 65 percent had only a very small piece of black belly lining on them and about 5 percent had both pieces of viscera and black belly lining. An inspector at the end of the cleaning machine should be able to remove bits of black belly lining with a plastic brush or by handpicking so that about 95 percent of the whiting would be completely clean. The remaining 5 percent could be recycled or hand-cleaned at the end of the run.

Although most of the black belly lining was removed by the two cleaning wheels and serrated roller at the end of the machine, it was observed that the 6-inch (15.2-cm) diameter cleaning wheels would only clean small fish whose belly flaps did not exceed 2.5 inches (6.35 cm) in size. The shaft on the wheel restrained the belly flap from being in full contact with the cleaning wheel. Since most of the whiting in the commercial trial were quite large, they tended to have belly flaps longer than those that could be cleaned by the 6-inch (15.2-cm) wheel presently on the machine. This is believed to account for the small amount of black belly lining remaining on the large whiting.

### Problems Encountered

In addition to the time lost for washing the machine during the run, several other problems were encountered. One of the major downtime problems was the binding of the shafts in certain sections of the machine. These shafts did not have sealed bearings, and fish juice which seeped into them tended to increase resistance forces until the shafts eventually stopped turning. Prior to each run, they were freed and oiled; but during the run, the fish juice would cause some shafts to stick and/or to stop turning.

Several other minor problems were encountered during the commercial runs. One of these was the turning of the fish head on the cleated conveyor prior to its being removed. Since only the body of the fish is supported by the conveyor, the head resting against a stationary flat plastic guide is retarded slightly under the frictional force as it is dragged along to the heading blade. This causes the part of the fish that meets the rotating heading blade to be cut at an angle. If the head were also conveyed on its own system, the cut could be made perpendicular to the axis of the fish for maximum yield.

Until recently, most conventional heading machines had this inefficient aspect, but the trend is now leaning toward the multiple metal pocket conveyor where the fish are secured in position while the head is being removed and other cuts are being made. This operation, which takes place at the operating speed of the machine, measures the head of the fish as it comes down the conveyor and clamps it in position to sever it at the correct angle for maximum yield. We have concluded that a higher and significant efficiency is possible and should be attained.

Another problem was the wetting of the electronic circuit boards, especially during clean-up operations. The circuitry had been mounted in waterproof housings and all connections had been made waterproof with rubber gaskets and other seals. However, during the moving of the machine from Gloucester to East Boston, Mass., the cables for power, water, and air had to be disconnected and reconnected at their destination. Subsequently, some of the connections leaked and, as a result, the main electronic circuit board broke down due to the water and had to be replaced. As a temporary measure, clear plastic covers were used to protect the electronic gear which will be redesigned so that the controls and other susceptible equipment would be completely protected.

During operation of the machine, a large amount of fish waste collected under it. This is acceptable in small operations; but in a large continuous operation, gurry conveyors should be installed. Most large fish processors already have these conveyors available; therefore, no design work is needed, only installation.

## Products From Whiting Machine

Although headed and cleaned whiting can be used as the starting material for a wide variety of fishery products, especially extrudable minced items (Mendelsohn, 1974a), only two types of whiting products—a frozen reverse-butterfly or pan-ready item and a frozen minced block—were prepared. The variety of product types was limited by the equipment that was available in the participating plant.

The pan-ready product needs no further processing and can be sold as a small consumer or large institutional pack. At the processing plant, the clean whiting were packed in layers (head to tail), separated by plastic sheets, in 10-pound waxed boxes and frozen in a plate freezer. After freezing, the boxes were placed into a master carton and the carton kept at −10°F (−23°C). National Marine Fisheries Service personnel and one industry member examined the pan-ready product made from very fresh whiting and judged it highly acceptable. The pan-ready product made from 5-6 day old whiting was judged as somewhat less acceptable due to its slightly "fishy" odor.

The frozen minced whiting blocks were made by putting the cleaned, headless whiting through the meat/bone separator. The minced product was then put into 18.5-pound waxed cartons and frozen in a plate freezer. After freezing, four blocks were placed inside a plastic bag and into a master carton. The cartons were then placed into a freezer held at −10°F (−23°C).

To determine the acceptance of these blocks, they were cut into fish sticks and battered and breaded. The results of an organoleptic evaluation of the sticks made from fresh whiting by laboratory personnel showed that they were highly acceptable. They received an overall score of 7.3 (good to very good).[4] Sticks made from the penned whiting (5-6 days old) using the same processing conditions were rated 6.4 (fair to good).

The largest quality differences between the penned whiting and day-boat whiting were recorded in their appearance and flavor. In the sticks made from the older fish, more black spots appeared because of their softer skin which tended to squeeze through the holes in the meat/bone separator drum and be collected with the edible portion.

## Recommendations and Conclusions

The result of our tests indicated that the prototype whiting processing machine performed largely as expected. However, the commercial operation uncovered the need to further modify it and to add accessory equipment in order to attain its maximum production potential.

Even though the throughput of the prototype machine is too low to meet the demand in the larger processing plants, there is still a sizeable economic advantage in using a machine of this type. Based on current labor practices in the Gloucester area, where fish processors pay about $7.70/hour (including fringe benefits) for general help and $8.65/hour for cutters and semiskilled workers, we have calculated the annual cost for processing a similar volume of fish using the prototype fish heading and cleaning machine and compared it with the cost of heading and cleaning the fish manually. We assumed that the cost of building the prototype machine to be $40,000. This estimate is based on our experience with other fish processing machines. Interest rates were calculated on 12 percent per annum, and the machine was amortized over a period of 5 years. Utility costs were calculated from actual commercial water and electricity bills. The total costs are itemized and tabulated in Table 1.

As shown in Table 1, using the prototype machine with its limited capacity could save a fish processor over $115,000 on a yearly basis. Coupled with a more consistently cleaned product of higher quality, we conclude that it would be worthwhile for a commercial whiting processor to purchase a machine similar to the prototype machine described in this article.

After careful consideration of the cost and complexity of the modifications needed to increase the speed and efficiency of the prototype heading and cleaning machine, we recommend building a completely new second generation heading and cleaning unit rather than modifying the existing prototype machine. The second generation model would have improved features to: 1) Increase throughput of fish; 2) lower number of rejects requiring further handling; 3) reduce down-time (for any reason); and 4) maximize effectiveness of operating components in the production line.

The new line of machines would be built around the successful engineering principles found in the prototype machine but would have a much larger throughput. In the smaller plants, one machine would be sufficient to handle their production while in the larger plants, as many as three machines would be installed, depending upon the amount of fish to be processed.

The proposed high capacity fish processing line is shown in Figure 2. Each unit would have a throughput of about 200 fish/minute; and if all three machines were operating at full capac-

Table 1.—Annual cost of processing whiting in the prototype machine vs. a manual operation[1].

| Item | Cost |
|---|---|
| Prototype machine | |
| Machine (amortized over 5 yr) | |
| Principal and interest | $ 10,690 |
| Maintenance | 5,000 |
| Labor | |
| 3 General help @ $16,016/yr | 48,048 |
| 1 Semiskilled help | 17,992 |
| Electricity | 903 |
| Water | 373 |
| Total | $ 83,006 |
| Manual operation | |
| Labor | |
| 11 Semiskilled help (cutters) @ $17,992/yr | $197,912 |
| Water | 186 |
| Total | $198,098 |
| Difference | $115,092 |

[1]Based on the need for 11 cutters for manual operation for the same production of fish cleaned using the machine and 4 people.

[4]Based on a scale of 9 to 1 where: 9 = excellent, 8 = very good, 7 = good, 6 = fair, 5 = borderline, 4 = slightly poor, 3 = poor, 2 = very poor, and 1 = inedible (Mendelsohn, 1974b).

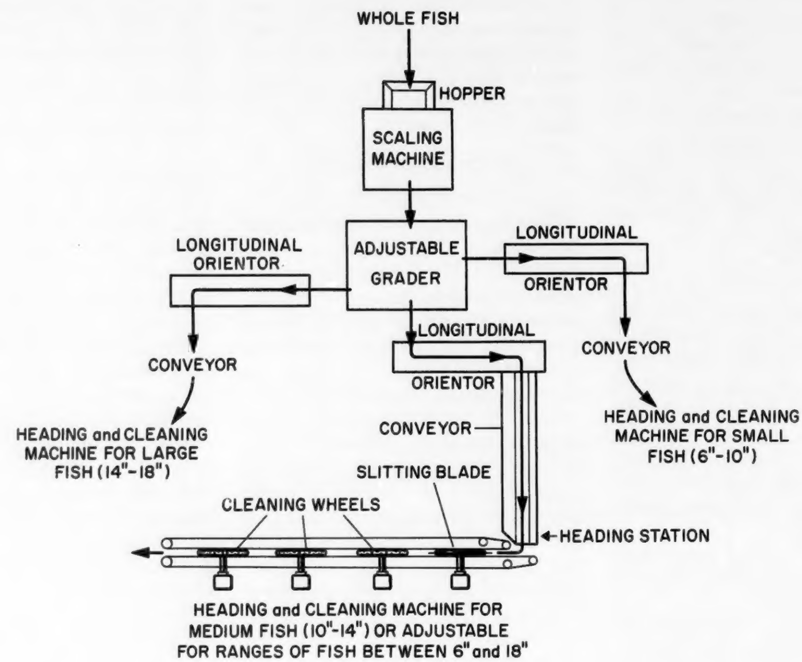


Figure 2.—Proposed high capacity processing line to head and clean 6-18 inch (15.2-45.7 cm) fish.

ity, the line would be able to handle 600 fish/minute varying within a size range from 6 to 18 inches (15.2-45.7 cm) in length.

As shown in Figure 2, the high capacity processing line would contain the following pieces of equipment:

1) An in-line rotary scaling machine to scale all the fish while they are still in the round. In the conventional processing of whiting, the scaling operation is done by a rotary scaler in a later part of the processing sequence. We are suggesting to do it as a first step when the fish are in the round to eliminate immediately the problems caused by the scales.

2) An adjustable size grader which will separate the fish into three size ranges, 6-10 inches (15.2-25.4 cm), 10-14 inches (25.4-35.6 cm), and 14-18 inches (35.6-45.7 cm).

3) A reservoir to hold each size of

fish until they are ready to be conveyed into a machine that: a) Orients the fish longitudinally, and b) orients the fish vertically.

4) A machine to position the fish to be loaded automatically four at a time onto the infeed conveyor.

5) A conveyor to move the fish into an automatic device which measures the length of the head and sets the cut-off knife to remove the head with a minimum loss of fish flesh.

6) An offloading device that transfers the fish to the processing conveyor where the fish is held in position between the carrier belts of the cleaning machine.

7) Semiautomatic air pressure controls to change the pressure adjustments to regulate: a) The depth of the rotary slitting blade used to open the fish's belly; b) the lateral pressure on the belts that hold the inner portion of the fish against the cleaning wheels; c) the vertical downward pressure on the hold-down rolls which keep the fish tight over the cleaning wheels that remove the viscera along the backbone. The size of the fish passing through the machine determines the pressure that each pressure control should apply to do the cleaning job without losing excessive fish flesh. Sorting the fish into three size categories and running one size category at a time makes it possible to adjust one set of regulators at a time to handle the one size category of fish to its best advantage. In a small plant with only one cleaning machine, each set of regulators would be preset and controlled by a selector switch to handle a single size range of fish. The size of the range would be no greater than 4 inches (10.2 cm) in length. By pressing the preselector button, the control system that had been in command for one size category would be shut off, and the controls for the size category to be run would be cut in. The time for switching controls will be in the order of 5 seconds. In the larger processing plants where three heading and cleaning machines are needed to handle their throughput, the controls on each machine would be preset for one size range of fish—also not to exceed 4 inches (10.2 cm) in the variability of length. Although each machine would have the capability of manually switching from one size range to another, it would be unnecessary when using the three machines. This system increases the effectiveness of the machines by matching the size range of the fish to the pressure range of the controls. One range of pressure settings does not work for a full size range of fish.

8) Cleaning wheels of increased diameter (from 6 inches (15.2 cm) to 12 inches (30.4 cm)) in addition to a third cleaning wheel.This change should greatly improve the quality of cleaning the belly cavity, especially in regard to the black belly lining in the larger fish. With a 12-inch (30.4-cm) cleaning wheel, the carrier belt can be 7 inches (17.8 cm) wide to hold the entire belly flap against the side of the wheel with optimum pressure to remove all of the black peritoneum. With three 12-inch (30.4-cm) cleaning wheels, the extension conveyor at the end of the present machine equipped with a conical skinning wheel to clean up the tips of the belly flaps will be unnecessary. This system should give adequate internal cleaning so that the carrier belts can release the fish directly onto the inspection belt which then drops the cleaned fish onto a conveyor for further processing.

9) Carriers with high belt speeds and a transfer system for conveying 12,000 fish/hour.

10) A large and efficient waste disposal system. In the prototype machine, the gurry disposal system was overtaxed necessitating shutdowns to clean the gurry ducts and areas where buildups occurred. A solution to this problem is to install one or more high pressure fan-jets at each station where fish parts and gurry accumulate. The hoses to the fan-jets would be secured to a rack connected to an air or hydraulic cylinder which would operate on time intervals of 15 minutes. At the preset time cycle, the hoses would make one traverse and then return to a starting position. Fish parts which had accumulated during the previous minutes would be washed down the gurry ducts to conveyors for quick removal, thus making it a smooth continuous operation and eliminating the need to stop the machine for cleaning.

A system of machines as described above is not only commercially feasible but is necessary for processing large quantities of fish between 6 and 18 inches (15.2 and 45.7 cm) in length to keep production costs competitive with costs in other food industries. Also, since more and more emphasis is being placed on quality, the proposed processing line would produce consistently high quality seafood products.

## Acknowledgments

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# A Survey on Whiting Fillet Blocks

CARMINE GORGA and KEVIN J. ALLEN

## Introduction

As a follow-up to the Combs report[1], the New England Fisheries Development Program, during the summer of 1978, began to test the economic feasibility of frozen blocks derived from machine-filleted whiting. A report[2] on this phase of the overall program was prepared in August 1978 and distributed to the industry. Concurrently, the Marketing Services Branch, NMFS, NOAA, laid the groundwork for an industry evaluation of the frozen blocks derived from that operation.

New England whiting is an abundant species which is not being fully utilized by the New England seafood industry. The present U.S. market for whiting is largely supplied by imported frozen whiting which is imported as H&G (headed and gutted), or as blocks which are then converted to portions for the food service industry. The H&G whiting is used by fish smokers and is also sold in retail packs (usually 5-pound boxes).

The purpose of a survey on whiting fillet blocks was to determine whether domestically produced frozen blocks made of machine-filleted whiting would be acceptable to U.S. converters.

## Survey Methodology

A cover letter and a questionnaire were prepared by the Marketing Services Branch in collaboration with the industry. The questionnaire was evaluated and pretested, both in-house and by a professional consultant. The cover letter, the questionnaire, and one case containing four 18.5-pound blocks of frozen whiting were delivered to processors and converters of frozen fish sticks and portions in August 1978.

With the exception of one West Coast converter, all blocks were hand-delivered by Marketing personnel. The vast majority of processors and converters is in the northeast region.

Questionnaires were independently completed and were returned to the Marketing Services Branch during September and October 1978.

## Percentage of Returns and Market Estimate of Respondents

Out of 18 questionnaires distributed, 14 were returned. Thus, there was a 78 percent response. Through direct knowledge of the respondents, it is estimated that this survey has covered 90-95 percent of the U.S. market of the frozen fish blocks processing industry.

## Findings

The first five questions were designed to obtain an evaluation of the frozen blocks. The next three questions were designed to elicit a comparison between whiting fillet blocks and other products existing on the market. The ninth question tried to determine the country of origin of existing blocks. Questions No. 10 and 11 tried to assess the market potential of whiting blocks as to prices and quantities. Question No. 12 solicited overall general comments; and question No. 13 tried to determine the potential interest of the respondent in the product. The analysis of the responses yielded the following information.

*Question No. 1.* "Would you say your overall reaction to this product is very favorable, somewhat favorable,

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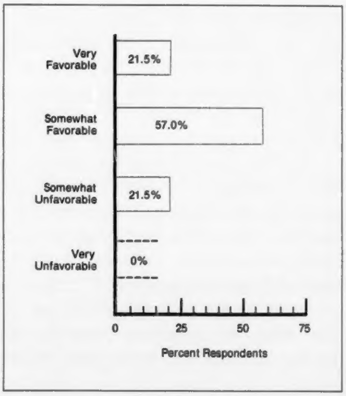


Figure 1.—Overall assessment of whiting fillet blocks by respondents.

[1]Combs, Earl R., Inc. 1977. Venture analysis and feasibility study relating to whiting and Atlantic mackerel. Contract Report No. 3-7-073-35121, 111 p. Fish. Dev. Div., NMFS, NOAA, P.O. Box 1109, Gloucester, MA 01930.

[2]Earl, P. M. 1978. Preliminary results of testing commercially available equipment for processing small whiting, *Merluccius bilinearis*. Preliminary Report, 16 p. Fish. Dev. Div., NMFS, NOAA, P.O. Box 1109, Gloucester, MA 01930.

**Whopping Fish Portion Burgers With Hot Curry or Greek Style Yogurt Sauce**

8 frozen fried whiting portions 3-4 ounces each
4 slices process American cheese, cut in quarters
8 hamburger buns or crusty oblong hard rolls
Hot curry or Greek-style yogurt sauce, or ½ recipe of each sauce
Lettuce (optional)
Cherry tomato slices
Green onions or assorted vegetables, relishes

Heat whiting portions in oven as directed on package label. Overlap two quarter cheese slices on each hot fish portion; return to oven just until cheese softens. Cut rolls or buns in half. Spread cut surface on each half with about 1 tablespoon of selected sauce. Cover bottom half of buns or rolls with lettuce leaf, if desired. Top with a fish portion. Garnish cheese with a dollop of sauce and cherry tomato slices. Cover with top half of bun or roll. Serve with green onions or vegetable relishes, as desired. Makes 8 sandwiches.

**Hot Curry Sauce**

1 cup salad dressing or mayonnaise
1 teaspoon curry powder
1 teaspoon paprika
1 teaspoon prepared mustard
1 tablespoon chopped parsley

Combine all ingredients; mix well. Makes 1 cup sauce.

**Greek-Style Yogurt Sauce**

1 carton (8 ounces) plain yogurt (1 cup)
¼ cup sliced green onion
¼ cup sliced pitted black olives
1 small clove garlic, minced
½ teaspoon grated lemon rind
½ teaspoon oregano

Combine and mix ingredients; chill if desired. Makes about 1¼ cups sauce.

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somewhat unfavorable, or very unfavorable?"

The majority of the respondents (8 or 57 percent) assessed their overall reaction to the blocks as "somewhat favorable." The remaining six were equally divided between a "very favorable" and a "somewhat unfavorable" overall assessment. None expressed a "very unfavorable" opinion (Fig. 1).

Converting the four categories of answers into a scale from 1 to 100, the blocks can be said to have received a 66 percent favorable rating[3].

*Question No. 2*. "What are the one or two best things about this product?"

Since this is a largely "qualitative" question, only those responses which could, have been tabulated in Figure 2; but without attaching any statistical value to the resulting numbers. All responses are quoted almost verbatim.

Responses from the "somewhat favorable" category of respondents:

1) "Good shape of block; whole

[3]Factoring in the absence of "very unfavorable" answers, this percentage can be raised to 82 percent. Averaging the two figures, one obtains a 75 percent favorable rating.

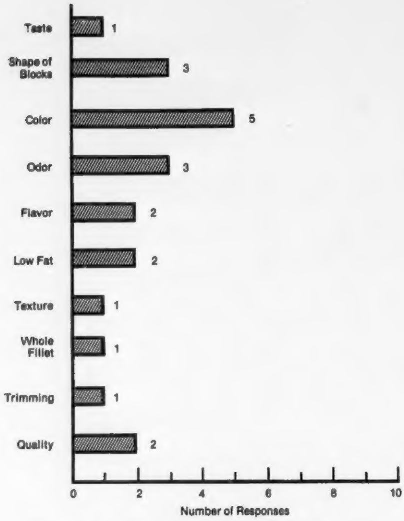


Figure 2.—Number of responses concerning the best features of whiting fillet blocks.

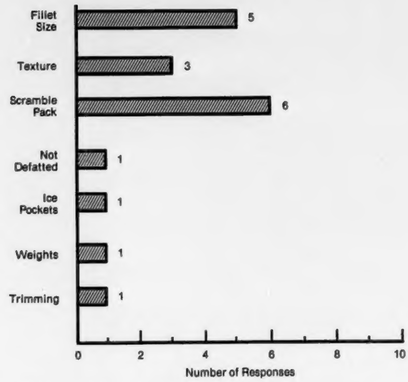


Figure 3.—Number of responses concerning the worst features of whiting fillet blocks.

fillets: very few bits and pieces."

2) "Fillet trimming, color and odor."

3) "The attempt to defat the fillets will help shelf life of blocks, if fillets are of good quality when packed."

4) "We would like to have more product."

5) "Flavor, low fat."

6) "It is a domestic resource. The proximity of this resource will permit greater control on overall product quality."

7) "Form and measurement of frozen blocks—flesh quality good."

8) "Good quality product—flavor, odor, and texture."

Responses from the "very favorable" category of respondents:

9) "Color was best attribute."

10) "Tasty."

11) "The product as a whole seemed to indicate that whiting blocks, if handled correctly, would become a product desired by processors."

Responses from the "somewhat unfavorable" category of respondents:

12) "Good overall fillet color, good odor."

13) "Good color, deep skinned material, good shape."

14) "Its color is whiter than South American whiting."

*Question No. 3*. "What are the one or two worst things about the product?" duct?"

Some responses have been tabulated in Figure 3. All responses are quoted almost verbatim.

Responses from the "somewhat favorable" category of respondents:

1) "Fillet size too small; slightly mushy texture."

2) "Blocks were scrambled pack—should be linear pack."

3) "Poor placement of fillets throughout block. Buying larger fillets (if possible) will help placement especially in terms of length pack or cross pack. The defatting did tear up some of the fillets."

4) "Unless there is some kind of subsidy, the U.S. fisherman cannot fish for whiting at present prices."

5) "Very small fillets."

6) "It is a seasonal species. The cost of blocks may make it unattractive at this time."

7) "Whiting not defatted."

8) "Small fillets, mixed pack, and ice pockets."

Responses from the "very favorable" category of respondents:

9) "Very acceptable product." (Presumably meaning no major negative features.)

10) "Weights were inconsistent."

11) "No comment."

Responses from the "somewhat unfavorable" category of respondents:

12) "Workmanship poor, fillet size small."

13) "Fillets poorly trimmed (cut pieces in block), randomly packed, fillet size very small, fillets mushy."

14) "It has a loose texture after cooking. The fillets are not packed in any particular alignment."

*Question No. 4*. "How do you rate the whiting block in terms of uniformity, odor, taste, texture, color, angles, and fillet size?"

One respondent did not make the analysis required to answer this question. (This respondent belongs to the "somewhat favorable" category.) The analysis of responses is graphically reported in Figure 4. That analysis yields the following ratings:

Uniformity of the blocks was judged "very satisfactory" by 3 of

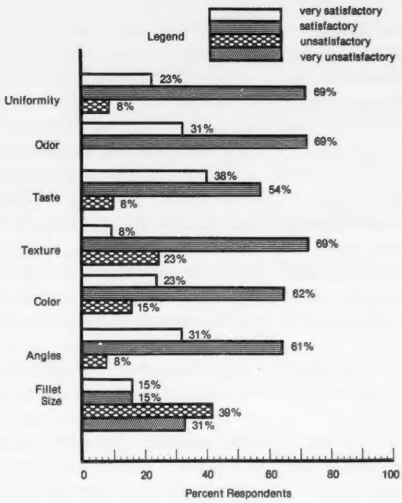


Figure 4.—Characteristics of whiting fillet blocks rated by respondents.

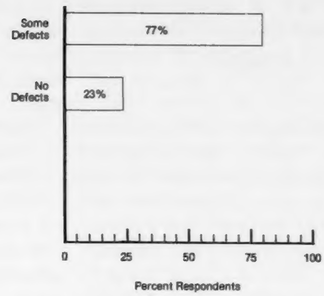


Figure 5.—Percentage of respondents finding defects with the whiting fillet blocks.

the 13 respondents (23 percent); "satisfactory" by 9 (69 percent); and "unsatisfactory" by 1 (8 percent). There were no "very unsatisfactory" answers. Odor was judged "very satisfactory" by 4 out of the 13 respondents (31 percent) and "satisfactory" by the remaining 9 respondents (69 percent). Taste was judged "very satisfactory" by 5 respondents (38 percent); "satisfactory" by 7 respondents (54 percent); and "unsatisfactory" by 1 respondent (8 percent). Texture was judged "very satisfactory" by 1 respondent (8 percent); "satisfactory" by 9 respondents (69 percent); and "unsatisfactory" by 3 respondents (23 percent). The last three respondents belonged to the "somewhat unfavorable" category. Color was judged "very satisfactory" by 3 respondents (23 percent); "satisfactory" by 8 respondents (62 percent); and "unsatisfactory" by 2 respondents (15 percent). Angles of blocks were judged "very satisfactory" by 4 respondents (31 percent); "satisfactory" by 8 respondents (61 percent); and "unsatisfactory" by 1 respondent (8 percent). Fillet size was judged "very satisfactory" by 2 respondents (15 percent); "satisfactory" also by 2 respondents (15 percent); "unsatisfactory" by 5 respondents (38 percent); and "very unsatisfactory" by 4 respondents (31 percent). (Percentages have been rounded off and in this case do not add up to 100.)

*Question No. 5.* "Did you find any defects in this product? If yes, please tell me exactly what defects you found."

One respondent did not provide any answer to this question. Out of the 13 remaining respondents, 10 (77 percent) did find some defects and 3 (23 percent) found no defects (Fig. 5). Each respondent who found some defects provided the following specific information:

"Small piece of glass."

"Small voids, slightly rounded edges, scrambled pack."

"Presence of fins, small piece of cartilage, some small pieces of what appeared to be spinal cord. (Any of above were not in excess.)"

"Block #1 had 3 fillets with pin bones. Block #2 had 1 fillet with pin bones. Some pieces of skin. Some fillets were not properly polarized."

"Fillets not defatted."

"Two small bones, and skin."

"Weights."

"Scramble pack, net weight below declared, dimensions inconsistent, voids, bruises, numerous pinbones, shrimp, roe, bacteria count high (A.P.C. 215,000 per gram)."

"Cut pieces attached to fillets, and back bones not completely trimmed away in a few cases."

"Three pieces of skin, 5 bones, 6 pieces of fin, 5 pieces of backbone, many scales."

The last three sets of answers belonged to the "somewhat unfavorable" category, while the fourth from the bottom belonged to the "very favorable" category. The other two respondents who belonged to the latter category found no defects.

*Question No. 6.* "Indicate how you rate the test product as compared with the whiting blocks you are now using in terms of uniformity, odor, taste, texture, color, angles, and fillet size."

Thirteen respondents answered this question which involved a comparison between the whiting blocks under examination and whiting blocks currently in commercial use.

Two respondents out of 13 (15 percent) found the blocks under examination "better" than those currently in

commercial use, 10 respondents (77 percent) found them "about the same"; and 1 respondent (8 percent) found them "worse" in terms of uniformity.

Four respondents (30 percent) found them "better" and 9 respondents (70 percent) found them "about the same" in terms of odor. Four respondents (30 percent) found them "better"; 8 respondents (62 percent) found them "about the same"; and 1 respondent (8 percent) found them "worse" in terms of taste. One respondent (8 percent) found them "better"; 10 respondents (77 percent) found them "about the same"; and 2 respondents (15 percent) found them "worse" in terms of texture.

Nine respondents (69 percent) found them "better"; 3 respondents (23 percent) found them "about the same"; and 1 respondent (8 percent) found them "worse" in terms of color. Two respondents (15 percent) found them "better"; 10 respondents (77 percent) found them "about the same"; and 1 respondent (8 percent) found them "worse" in terms of angles. One respondent (8 percent) found them "better"; 3 respondents (23 percent) found them "about the same"; and 9 respondents (69 percent) found them "worse" in terms of fillet size.

Perhaps the above data become more meaningful if the responses relating to the categories "about the same" and "better" are combined together, and the results are presented as in Figure 6.

*Question No. 7.* "In your opinion, what are the major advantages this new product offers as compared to the blocks you are now using?"

Responses are again quoted almost verbatim

"Would expect more consistent quality from domestic fishery."

"New source of supply. Price—could be cheaper? Better consistency in terms of quality."

"Flavor not as strong."

"The proximity of the resource."

"None."

"There appear to be no advantages."

"Color and flavor."

"U.S. product. Would imagine sanitary conditions under which blocks are being produced would be better than blocks from foreign countries."

"Color. Angles."

"None."

"None. No advantages."

"It lacks the strong odor often present in whiting and has better color."

*Question No. 8.* "What are the disadvantages of the new product compared with the blocks you are now using?"

One respondent left the answer blank. Responses are quoted almost verbatim.

"Fillet size too small."

"Potential fracturing of pieces cut from scramble packed blocks."

"Not familiar enough with the characteristics of this type of whiting, and with problems—if any—it could pose after packing and processing."

"Fillet size, jumble pack. May have trouble with chopper."

"Seasonal species. Definite flavor, while we try to utilize fish with a bland flavor."

"Needs defatting."

"Small fillet size, mixed pack, ice pockets."

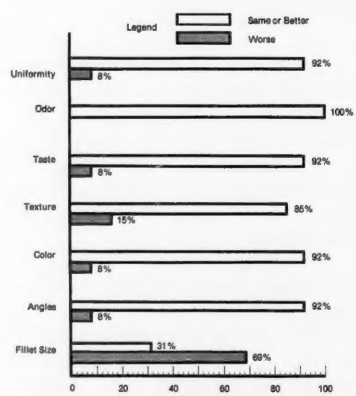


Figure 6.—Characteristics of test whiting fillet blocks compared with those of whiting blocks presently used by respondents.

"None."

"None."

"Could be price."

"Inconsistent workmanship, scramble pack and small fillet size."

"Fillet size and mushiness."

"It has far too many defects. This block could not make a Grade A portion; it does not even reach the Grade A standard for blocks."

These comments have been presented in the same order as those quoted earlier under questions number 2 and 3.

*Question No. 9.* "Please indicate the country or origin from which you purchased the following: whiting, cod, haddock, flounder, ocean perch, and pollock blocks. Include country of origin and quantity purchased each year."

Six out of the 14 respondents (43 percent) did not answer this question. Among those who answered, one did not provide any quantities and a second provided only percentages presumably relating to his own production but without indicating that total. Also, to avoid potential disclosure of confidential information, the following quantities are tabulated by species without correlating them with their disclosed country of origin.

Whiting blocks were bought from Argentina, Uruguay, Chile, South Africa, and Peru. Approximate yearly totals: 11,500,000 pounds. Cod blocks were bought from Canada, Denmark, Iceland, Norway, Greenland, Scotland, Faroe Islands, and the United States. Approximate yearly totals: 18,000,000 pounds. Haddock blocks were bought from Canada, Norway, Scotland, Iceland, Denmark, and Faroe Islands. Approximate yearly totals: 5,500,000 pounds.

Flounder blocks were bought from Canada, Iceland, Norway, and Scotland. Approximate yearly totals: 5,500,000 pounds. Ocean perch blocks were bought from Canada, Iceland, and Norway. Approximate yearly totals: 500,000 pounds. Pollock blocks were bought from Canada, Japan, Korea, Iceland, Norway, Scotland, Faroe Islands, and United States. Approximate yearly totals: 9,500,000 pounds.

*Question No. 10.* "At what price level would you purchase this product and what amount would you purchase?"

Three respondents answered this question and one stated that he would not buy any frozen whiting blocks even at 40 cents per pound. One respondent indicated that he would buy "at the most" 1,000,000 pounds and "at the least" 500,000 pounds per year if the price ranged between 40 cents and 50 cents per pound; at 60 cents per pound he would buy 500,000 and 150,000 pounds, respectively. There would be no purchases at higher prices.

The other respondent indicated he would buy "at the most" 600,000 pounds and "at the least" 200,000 pounds if the price ranged between 40 cents and 60 cents per pound. At 65 cents per pound, purchases would be reduced to 500,000 pounds and 150,000 pounds, respectively. At 70 cents per pound, purchases would be further reduced to 350,000 pounds and 100,000 pounds respectively. At 75 cents per pound, the respondent would buy 200,000 pounds per year "at the most." At 80 cents per pound, he would buy "at the most" 100,000 pounds per year. Beyond that price, the demand would be reduced to zero.

*Question No. 11.* "Would you consider substituting this product for cod or haddock?"

Two respondents did not give any answer to this question. Three out of 12 respondents (25 percent) indicated they would substitute whiting blocks for both cod and haddock blocks. The remaining 9 respondents indicated that they would not (Fig. 7).

*Question No. 12.* "Do you have any comments or suggestions regarding this product?"

Five out of 14 respondents did not give any answer to this question. The remaining nine answers or sets of answers were as follows:

"Is this sample representative of a production run or a 'hand made sample'?"

"I believe this is a good idea. It could open up interest in other areas of fish processing."

"We are producers of blocks. We are not processors."

"Need a steady supply at competitive price."

"This product appears to have potential. Some of the whiting fillets in the block were starting to turn color. The keeping quality of this fish in the fresh state presents a problem because it has a short shelf life."

"We would have to be assured of continuous supply of top quality blocks at competitive prices."

"The fillet size appears to be the cause of many of the defects in workmanship."

"Vast improvements in raw material are necessary before we would even begin to consider this product in our production."

"Silver hake is a low quality fish. It should not be compared with cod and haddock and could do great harm to the fish industry if promoted."

*Question No. 13.* "This product is not now available in the marketplace. If it should become available, would you wish to be contacted by a domestic supplier?"

Of the 14 respondents, 13 stated they would like to be contacted by a domestic supplier if whiting blocks became available in the market.

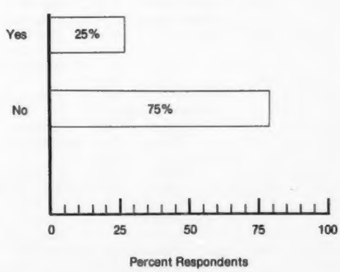


Figure 7.—Percentage of respondents who would consider substituting whiting fillet blocks for cod and haddock blocks.

## Comments

This survey has produced some valuable information on the potential market for domestically produced frozen whiting blocks. To recapitulate the major findings:

1) 57 percent of the respondents indicated that they currently buy approximately 11,500,000 pounds of whiting blocks per year from a number of foreign countries;

2) 92 percent of the respondents found the whiting blocks under evaluation either "better" or "about the same" in terms of uniformity; 100 percent of the respondents found them either "better" or "about the same" in terms of odor; 92 percent found them the same in terms of taste; 85 percent in terms of texture; 92 percent in terms of color; 92 percent in terms of angles; but only 31 percent found the blocks either "better" or "about the same" in terms of fillet size.

3) 25 percent of the respondents indicated that they would consider substituting the product under evaluation for both cod and haddock blocks.

This survey has produced little or no information in relation to the price that U.S.-produced whiting blocks might command on the market. The only two respondents who answered the pertinent question indicated that they would accept a 40-60 cents per pound price range.

The bulk of the information produced by this survey relates to the technological aspects of the product. Both the qualitative and the quantitative information provided by the industry and collated here should prove useful to the potential producer of whiting blocks.

Perhaps the most indicative summary figure of the technological characteristics of these blocks is the 66 percent (or 75 percent weighted average) overall favorable rating given to the product by the respondents.

# Markets for Hake

IRENE S. GENDRON

## Introduction

The United States fishing industry participates in commercial fisheries for four hake species. Three of these, silver hake (whiting), *Merluccius bilinearis*; red hake, *Urophycis chuss*; and white hake, *Urophycis tenuis*; are harvested off the coasts of the New England and Mid-Atlantic states, and the fourth, Pacific whiting, *Merluccius productus*, is found off the coasts of Washington, Oregon, and California. Hakes, primarily of the *Merluccius* genus, are also imported in sizeable quantities by the United States, usually from South American, South African, and New Zealand waters.

Like other members of the Gadidae family found in the U.S. Fisheries Conservation Zone such as Atlantic cod, *Gadus morhua*; cusk, *Brosme brosme*; and walleye (Alaska) pollock, *Theragra chalcogramma*; hakes are white-flesh, mild-flavor, low-fat demersal fish (Brand Group, Inc., 1978). Although in a broad sense there is some substitutability in the marketplace among the various white-fleshed fishes, each species, including the four U.S. hakes, has its own unique characteristics which are taken into account by processors and consumers and which influence product form, price, market demand, and consumption patterns. In the following sections, markets for each of the four hakes are described individually and in the context of the general market for all bottomfish products.

*ABSTRACT—Four hake species are commercially harvested by the United States: Silver hake (whiting),* Merluccius bilinearis; *Pacific whiting,* Merluccius productus; *red hake,* Urophycis chuss; *and white hake,* Urophycis tenuis. *This paper describes present U.S. domestic and export markets for these species and examines the potential for market expansion both as a substitute for imported hakes and other similar bottomfish and from new product development. The potential for market growth appears excellent for silver hake and could be substantially improved for other hakes once technological and other impediments to developing the fisheries for these species are solved.*

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## Silver Hake (Whiting)

Silver hake, hereafter referred to as whiting in accordance with current industry usage, has been an established food fishery since the 1920's. Whiting is generally sold either round or dressed in fresh fish markets from New England south to Virginia or frozen headed and gutted (H&G) and distributed throughout the nation with the majority of sales in the Northeast, Mid-Atlantic, and Midwest states.

Table 1 shows 1976 landings, process forms, and values for whiting landed for food fish and is generally representative for the period 1971-77.

In 1978, landings were 51.1 million pounds, the highest since 1968, and the average ex-vessel price rose to a historic high of $0.14 per pound (U.S. Department of Commerce,

**Table 1.—Utilization of U.S. whiting, *Merluccius bilinearis*; food fish landings, 1976.**

| Landings and products | Volume (in pounds) | Value (in dollars) | Value per pound | Number of processing plants[1] |
|---|---|---|---|---|
| Landings[2] | | | | |
| Maine | 407,555 | 28,620 | $0.070 | |
| Massachusetts | 29,440,407 | 2,375,750 | .081 | |
| Rhode Island | 7,284,065 | 530,174 | .073 | |
| New York | 2,545,869 | 289,655 | .114 | |
| New Jersey | 7,915,059 | 743,325 | .094 | |
| Other[3] | 73,045 | 5,476 | .075 | |
| | 47,666,000 | $3,973,000 | $0.083 | |
| Products[4] | | | | |
| Headed & gutted | | | | |
| Fresh | 54,688 | 22,397 | $0.410 | 2 |
| Frozen | 9,906,323 | 3,547,728 | .358 | 6 |
| Fillets | | | | |
| Fresh | 30,000 | 22,500 | .750 | 1 |
| Frozen | 963,771 | 601,868 | .624 | 4 |
| Frozen/cooked | 61,800 | 33,322 | .539 | 1 |
| Fillet blocks | 24,486 | 11,018 | .450 | 1 |
| Cured | 1,065,127 | 804,889 | .756 | 10 |
| Fresh round[5] | 24,698,306 | 7,903,458 | .320 | |

[1]Some plants may process more than one product form and are listed under each category.
[2]Landings in round weight volume and ex-vessel value.
[3]Small amounts from Connecticut, New Hampshire, Delaware, Maryland, Virginia, and North Carolina.
[4]Products in processed weight volume and first wholesale value.
[5]Earl R. Combs, Inc. estimate from field study.
Sources: U.S. Department of Commerce. 1976. Processed fishery products. Computer print-out. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Washington, D.C. Robinson (1977). U.S. Department of Commerce (1978a,b,c,d,e).

1979). Preliminary indications are that H&G, fillet, and cured production in 1978 was approximately at 1976 and 1977 levels, thus implying an increase in fresh, round sales. Assuming a continued upward trend in landings, additional processing capacity and marketing effort would be necessary. The largest market potential appears to be in development of the fillet block market.

### Fresh Whiting

Whiting is sold in the round to local fresh markets, primarily in ethnic communities existing in fishing ports and large cities of the Northeast and Mid-Atlantic states. These ethnic communities are largely populated by people of Black or Mediterranean heritage. Most New England landings not sold locally are trucked to the Fulton Fish Market in New York. When supply exceeds demand in the Fulton market, the surplus whiting are sold to markets in Delaware, Pennsylvania, Maryland, and Virginia. There is currently no market for fresh whiting south of Virginia. Indications are that existing markets for fresh whiting are saturated. New fresh markets could only come about by expensive advertising which is economically unattractive to the industry.

### Headed and Gutted (H&G)

For H&G a 6- to 8-ounce headless fish is desired. It is packed in cardboard cartons holding 1½, 3, 5, or 10 pounds. Retailers often prefer 1½- or 3-pound cartons so they do not have to thaw and repackage prior to sale. Frozen H&G is an inexpensive product, retailing at approximately $0.79 per pound, and is especially popular in Black and Spanish-speaking areas of the East and Midwest. At least one processor of H&G has recipes and labeling in Spanish as well as English on the box.

At present, domestic H&G production does not fill the U.S. demand for H&G. In 1978 approximately 6 million pounds of H&G were imported, primarily from Argentina, Peru, and South Africa (Table 2).

South American whiting often has a few cents per pound price advantage over domestic and South African whiting. Poor quality product, especially from Peru *(Merluccius gayi)*, has tended to limit the U.S. demand for South American H&G. Although some buyers still import Peruvian whiting for price considerations, many no longer do so, believing the low price does not justify the sacrifice in quality.

Conversations with retailers and wholesalers within the past year indicate that U.S. H&G is of good quality and price but is in limited supply. Several buyers indicated a willingness to purchase more domestic H&G if it were available in sufficient quantities on a sustained basis. It would appear that there is at least modest potential for expansion of domestic H&G markets, as a minimum to substitute for some of the 6 million pounds of imported product and possibly to service new markets which would open in response to a good quality, moderately priced product with steady supply.

### Fillets and Fillet Blocks

The United States imported approximately 20 million pounds of whiting fillets in 1978 (Table 2). Domestic production was only about 1 million pounds. Domestic fillets were hand cut, mostly from larger whiting. Most whiting landed domestically are under 1 pound round weight and yield fillets under 3 ounces in weight. There appears only limited potential for expanding the fillet market since most users prefer a 4-ounce minimum fillet size (Earl R. Combs, Inc., 1977). The small fillets can be used in fillet blocks, however.

Market expansion appears more feasible for fillet blocks. During the past several years an increasing amount of whiting fillet blocks have been imported for secondary processing into breaded and battered sticks and portions. United States production of whiting fillet blocks has been insignificant with only 24,000 pounds processed in 1976 (Table 1), compared with 20.6 million pounds of imported blocks (Bell and Fitz Gibbon, 1977). Table 3 shows the volume and species composition of U.S. block imports in 1977 and 1978.

United States per capita consumption of sticks and portions manufactured from blocks reached a record 2.17 pounds in 1978 and trend analysis projects future continued growth (U.S. Department of Commerce, 1979). Cod

**Table 2.—U.S. imports of whiting, 1978.**

| Country | Imports (1,000 pounds) | | | | |
|---|---|---|---|---|---|
| | Block | Fillet | Minced | Dressed | Total |
| Argentina | 17,443 | 11,786 | 146 | 1,022 | 30,397 |
| Brazil | 1,125 | 524 | | | 1,649 |
| Canada | 14 | 5 | | | 19 |
| Chile | 1,247 | 2,603 | | 98 | 3,948 |
| Denmark | 205 | | | | 205 |
| Faroe Islands | 394 | | | | 394 |
| Iceland | 1,260 | 46 | | | 1,306 |
| Japan | 2,532 | 187 | 37 | | 2,756 |
| Korea | 3,092 | | | | 3,092 |
| Peru | 1,422 | 400 | | 1,165 | 2,987 |
| Scotland | 721 | 86 | | | 807 |
| Singapore | | 2 | | | 2 |
| South Africa | 2,861 | 2,805 | 1,156 | 3,164 | 9,986 |
| Spain | 220 | 129 | | | 349 |
| Sweden | 62 | | | | 62 |
| Uruguay | 3,232 | 1,422 | 36 | 299 | 4,989 |
| West Germany | 441 | | | | 441 |
| Total | 36,271 | 19,995 | 1,375 | 5,748 | 63,389 |

Source: L. Chaves-Michael, Northwest Regional Office, NMFS. Compiled from imports in all Fishery Market News Reports.

**Table 3.—U.S. imports of regular and minced fish blocks and slabs, by species and type, 1977 and 1978.**

| Species and type | 1977 Imports | | 1978 Imports | |
|---|---|---|---|---|
| | 1,000 lb | $1,000 | 1,000 lb | $1,000 |
| Regular blocks & slabs | | | | |
| Cod | 204,872 | 183,371 | 204,696 | 190,971 |
| Flatfish | | | | |
| Turbot | 4,594 | 2,944 | 4,352 | 2,684 |
| Other | 10,496 | 11,274 | 12,425 | 12,347 |
| Haddock | 30,815 | 27,023 | 27,026 | 26,101 |
| Ocean Perch, Atlantic | 2,291 | 1,516 | 3,084 | 2,405 |
| Pollock | 82,960 | 41,680 | 81,294 | 50,560 |
| Whiting | 22,402 | 11,137 | 39,817 | 22,885 |
| Other | 8,091 | 6,063 | 14,231 | 9,730 |
| Total | 366,521 | 285,008 | 386,925 | 317,683 |
| Minced blocks & slabs[1] | 18,617 | 6,686 | 19,361 | 7,684 |
| Grand total | 385,138 | 291,694 | 406,286 | 325,367 |

[1]Most of the shipments were from Canada, Iceland, and Denmark.
Source: U.S. Department of Commerce, (1979).

is still the preferred species for battered portions, especially for restaurant use, but demand for whiting is growing, both as a cod substitute and to service new demand for whiting as a unique product in itself. Increasing numbers of buyers are reportedly asking for whiting by name rather than settling for whiting only when cod is not available.

It is estimated that almost one-half of 1978 whiting block imports were defatted whiting *(Merluccius hubbsi)* from Argentina. Defatted whiting is preferred by many buyers because removing the layer of fatty tissue leaves a pure white fillet comparable in appearance to cod and reduces the incidence of rancidity. Defatted whiting is significantly lower-priced than cod although more expensive than regular whiting and pollock blocks. In 1978 defatted whiting blocks were wholesaling FOB Boston for an average $0.80 per pound versus $1.00 for cod, $0.60 for regular whiting, and $0.69 for Alaska pollock.

The New England whiting industry, in conjunction with the National Marine Fisheries Service, has already begun limited machine processing of whiting fillet blocks. There is a production-scale demonstration project supported by the New England Fisheries Development Program scheduled for this year. Assuming favorable economic results and good quality production, there appears to be excellent opportunity for U.S. whiting to substitute for imported blocks as well as to service new market growth.

### Cured

Total U.S. cured production of all species in 1976 was 54.5 million pounds with salmon and herring combined composing 69 percent of the total and whiting only 2 percent.[1] Production of cured (smoked) whiting has been stable over the past decade at approximately 1 million pounds annually, and significant increase is not projected in market size.

### Industrial

In 1974, 4.7 million pounds of whiting were landed for reduction into fishmeal (Bell and Fitz Gibbon, 1977). In addition to the whiting caught specifically for industrial processing, a much larger amount is landed as part of the mixed industrial loads generally selling for $0.02 per pound ex-vessel. In 1977, 5.9 million pounds of mixed industrial fish were landed in Maine and 12.9 million pounds in Rhode Island (U.S. Department of Commerce, 1978c, d). It has been estimated that whiting constitute a large portion of these mixed industrial fish (Olsen and Stevenson, 1975).

In general, a large catch of whiting over several days causes an oversupply on the fresh fish market which results in a decline in the ex-vessel price. Fishermen often do not feel it is economically justifiable to sort fish for the food market when the ex-vessel price falls below $0.04 or $0.05 per pound. Under these conditions they will pack the hold with as much unsorted fish as possible hoping that the large quantity will compensate for the low price they will receive in the industrial market. There is little motivation to expand the whiting industrial fishery. Generally fishermen will land whiting for industrial use when food fish ex-vessel prices are low in an attempt to salvage a day's fishing effort. Increased markets and processing capacity for food fish would be much preferred by fishermen (Earl R. Combs, Inc., 1977).

### Export Markets

At present export markets for U.S. whiting do not exist. There has been increased interest in the United States to export whole fish to Nigeria and other African nations, but it appears likely that the offered price will not be sufficient to attract industry to produce a whole-frozen product from whiting currently selling ex-vessel at about $0.14 per pound.

In southern Europe, especially Italy, there are markets for whiting estimated at over 100,000 t per year. Demand is highest, however, for larger headed and gutted weight whiting (over 9 ounces, finished weight). Most U.S. whiting are not large enough to produce this size of product. Although demand exists in Southern Italy for a 5- to 9-ounce fish with only the tail and fins removed, tariffs, taxes, and shipping and handling charges do not make export of these smaller fish profitable (Fisheries Development Ltd., 1975).

## Red Hake

United States red hake, *Urophycis chuss,* landings in 1978 were only 4.8 million pounds with an average ex-vessel price of $0.11 per pound (U.S. Department of Commerce, 1979). Only 10,000 pounds were reported as processed into fresh fillets in 1976 at a wholesale price of $0.98 per pound (see footnote 1). The remaining fish were sold whole to fresh fish markets including the Fulton Market in New York and the Baltimore Wholesale Market.

Most red hake is white-fleshed although occasionally ruptured blood vessels can cause a pink hue to the flesh. It is often prepared in the traditional New England method of corned hake with pork scraps and is also used for chowder and fish salad.

There are several problems that tend to limit red hake's marketability. It has softer flesh than whiting or cod (Brand Group, Inc., 1978). Also, the name "hake" is not as familiar to consumers as the "whiting" nomenclature used for silver hake. At present, fillet blocks prepared from red hake have been of unsatisfactory quality because the flesh develops a rubbery texture. Research is currently underway to try to see if an acceptable red hake block can be produced.

Red hake is also a component of the mixed industrial fishery described in this paper for silver hake. As is the case for silver hake, use of red hake for food fish is economically preferable to increased industrial use.

[1]U.S. Department of Commerce. 1976. Processed fishery products. Computer print-out. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Washington, D.C.

## White Hake

In 1976, 9.1 million pounds of white hake were landed in New England at an average ex-vessel price of $0.133 per pound (Robinson, 1977). Seventeen firms processed a total of 803,172 pounds of fresh fillets at an average wholesale price of $0.93 per pound; two firms processed a total of 614,990 pounds of frozen fillets at an average wholesale price of $0.50 per pound; three firms processed a total of 76,800 pounds of cured products at an average wholesale price of $0.51 per pound (footnote 1). The remainder of white hake was sold to fresh fish markets, primarily in New England, New York, and Baltimore.

Even though white hake is white-fleshed and mild-tasting, its market potential is limited at present. As in the case of red hake, white hake is softer fleshed than whiting and consumers are often unfamiliar with the product name "hake."

Canadian fishermen landed 23.3 million pounds of white hake in 1977. Approximately 1.7 million pounds of cured white hake were exported to the United States as well as fresh and frozen fillets and fillet blocks of an unavailable amount (Government of Canada, Fisheries and Oceans, 1977). Estimates from NMFS for 1978 show 1.3 million pounds of fresh and frozen hake imports from Canada (U.S. Department of Commerce, 1978f). It would appear that if U.S. industry could process white hake at a competitive price there could be some opportunity to substitute U.S. white hake for some portion of Canadian hake imports.

## Pacific Whiting

Pacific whiting, *Merluccius productus*, like whiting (silver hake) and other species of the genus *Merluccius*, is a white-fleshed, mild-tasting fish. Historically, Pacific whiting has been landed by U.S. fishermen primarily for the industrial meal fishery with only small amounts being headed and gutted or filleted for human consumption. For example, in 1974 5.3 million pounds were landed of which 1.6 million pounds were used for frozen animal food, 35,000 for canned animal food, 3.6 million pounds for meal and oil, and only 27,000 pounds for human consumption (Bell and Fitz Gibbon, 1977).

Only in 1978 have significant quantities of Pacific whiting been marketed for human consumption. During that year U.S. landings were 7.3 million pounds (U.S. Department of Commerce, 1979). Assuming 1974 levels for industrial use, some 2 million pounds were processed into fillets and headed and gutted product for human consumption.

The ex-vessel price averaged only $0.03 per pound for all uses of hake. the first wholesale price for H&G was about $0.39 per pound and for fillets about $0.79 per pound. Pacific whiting is presently very competitively priced with other hake and bottomfish products. As the fishery develops, ex-vessel prices can be expected to rise but the addition of large-scale, mechanical processing should be more efficient than current smaller-scale hand processing operations and wholesale prices should remain about constant.

The west coast fishing industry is showing strong interest in developing large-scale markets for Pacific whiting. Current optimum yields for the stock have been set at 175,000 t. Most of this resource is currently allocated to foreign fisheries (Earl R. Combs, Inc., 1979b).

Fillets, fillet blocks, and H&G forms are produced from Pacific whiting. Several impediments to market development do exist, however, and need to be dealt with before development of the fisheries can proceed.

### Impediments to Market Development

The skin of Pacific whiting tends to be thinner than other commercially harvested species and the flesh is tenderer. Pacific whiting also exhibits a substantial incidence of a myxosporidian parasite in the flesh. This parasite releases an enzyme upon death of the fish that breaks down the muscle tissue and causes the flesh to become mushy and, thus, unacceptable to consumers (Earl R. Combs, Inc., 1979b).

Laboratory research has already been able to chemically neutralize the parasitic action in minced Pacific whiting but until a method is commercially available which is economically competitive with other product forms and approved by the U.S. Food and Drug Administration (FDA), marketing efforts will need to work with this problem.

Apparently the parasitic action can be curtailed if Pacific whiting is deep-fried quickly at high temperatures. Institutional users generally cook breaded and battered fish this way whereas retail consumers often do not. Processing Pacific whiting into fillet blocks and targeting on the institutional market for sticks and portions may be one method of entering the market with a quality product (Earl R. Combs, Inc., 1979b).

Concerns have also been voiced by buyers about the fragility of Pacific whiting fillets which often break apart upon handling before cooking. Processing fillet blocks rather than individual fillets could also solve this problem.

There is another problem relating to the large-scale development of H&G Pacific whiting in addition to those caused by soft flesh and nomenclature. Consumers are generally used to buying New England and imported H&G which measure about 6-8 inches and are packaged in 10-inch cartons. Pacific whiting are generally about 14 inches, H&G, and do not fit readily into the traditional size carton. In addition to recipes for deep-fry cooking methods and consumer education as to the similarity of Pacific whiting to whiting, it will also be necessary to develop innovative packaging to aid in marketing Pacific whiting.

### New Product Development

Some Pacific whiting is currently being minced and combined with shrimp in a breaded product called "Shrimbos[2]." Currently marketed only

[2]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

near Astoria, Oreg., this product is similar to one introduced by a major nationwide fish processor and shows good marketing promise. Consumers are less apt to read labels in mixed species or breaded products sold as "fish" which should lessen the possible resistance to the name Pacific hake, the name formerly used for Pacific whiting. Also, products with many ingredients such as Shrimbos or chowders could lessen the consumer's notice of any slight mushiness in the flesh which might be unacceptable in a pure Pacific whiting product. Further developmental work is needed to find new products where the fragile characteristics of the Pacific whiting flesh are not a deterrent to consumer satisfaction.

**Export Markets**

The presence of parasites eliminates major European markets for Pacific whiting (Fisheries Development Ltd., 1975), but other possibilities exist for export. Further developmental work could perhaps establish export markets for dried Pacific whiting ("stockfish") and cured, salted Pacific whiting. Africa, the Caribbean, and South America currently consume substantial stockfish quantities of these products. Although cod is the traditional stockfish species, hake is increasingly utilized as a low-priced substitute (Food and Agriculture Organization of the United Nations, 1978). Nigeria, for example, imported 101,956 t of stockfish in 1976 (Earl R. Combs, Inc., 1979a). Parasitized Pacific whiting, where enzyme action has already caused flesh changes, is probably not suitable for quality dried products and quality control will need to be stringent.

Other nations, primarily the Soviet Union, Poland, Bulgaria, and the German Democratic Republic, harvest substantial quantities of Pacific whiting. In 1976 the world harvest of Pacific whiting was 237,012 t (Food and Agriculture Organization of the United Nations, 1977). Since these nations engage in limited trade and information exchange on markets with the United States, it is not known how or whether they neutralize the parasite problem in Pacific whiting. Although some arrangements are already in effect between the U.S. and the U.S.S.R. for transfer at sea of U.S. landed Pacific whiting, more work would be necessary by the Pacific whiting industry to fully evaluate the potential of exporting Pacific whiting to those nations currently harvesting it.

## Conclusion

As United States usage of bottomfish fillet blocks increases, there are opportunities for U.S. processed hake blocks to substitute for imported blocks and supply new market demands. Although all U.S. hakes are white-fleshed and mild-tasting, only silver hake has a consistently firm flesh texture which makes it comparable with most imported whitings and cod. More technological research in improving flesh consistency is necessary before Pacific whiting, red hake, and white hake blocks can become fully developed markets.

There is also potential to substitute for imported products and develop new markets in the United States and abroad for headed and gutted, filleted, cured, minced, and chowder products. However, impediments caused by variations in species size, texture, and nomenclature will need to be counteracted by innovative marketing techniques before full market potential is realized.

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# Frozen Storage Characteristics of Whiting Blocks

JOSEPH J. LICCIARDELLO, ELINOR M. RAVESI, AND MICHAEL G. ALLSUP

## Introduction

The total catch of whiting, also known as silver hake, *Merluccius bilinearis*, in 1977 in the northwest Atlantic ranging from the Gulf of Maine to the Middle Atlantic States was 80,773 tons (Anonymous[1]). Of this total amount, the U.S. commercial catch amounted to 21,960 tons. The optimal yield for the whiting stocks for 1977 was set at 115,000 tons (Anonymous, 1977). It is obvious that the United States is not utilizing this resource to the fullest potential.

There is a limited domestic market for whiting which is sold either in the round for the fresh trade, or as frozen fillets or frozen headed and gutted (H&G). Only the large whiting which represent a small portion of the catch are filleted (by hand) for freezing. The market for the traditional H&G pack, which probably represents the major processed form sold, has at times been jeopardized by a similar imported product offered for sale at a lower price (Anderson and Mendelsohn, 1971). This competition has stimulated an interest among processors for new product forms and new markets.

Up to this time, there has not been available a filleting machine capable of handling the small, average-sized (about 12 inches) whiting in a large-scale operation, and hand filleting small whiting is impractical because of the economics involved (Peters et al., 1964). However, recently two different machines, the Arenco[2] SFA-4 and the Baader 121, which are reputed to automatically fillet small whiting, have been developed. It is realized that the production of fillets from average size whiting offers the greatest hope for expansion of the domestic whiting industry (Combs[3]). Skinless fillets could be used for the production of frozen blocks for which a potentially large market would be created for the manufacturers of fish sticks and portions.

A most efficient method for recovering fish flesh from small, bony, or otherwise difficult to fillet fish is by use of meat-bone separators. With this equipment, the yield of flesh from headed and gutted whiting was found to be 86 percent (King and Carver, 1970) compared with about 60 percent by hand filleting. The comminuted flesh produced by this process can be formed into frozen (minced) blocks which also would be potentially suitable for the production of fish sticks and portions, though not as desirable as fillet blocks. Thus, these two primary product forms of whiting, fillet and minced blocks, could serve as a market outlet to support an expanded fishery.

The purpose of this study was to determine the frozen storage characteristics of minced or fillet whiting blocks at various temperatures to evaluate their suitability as a raw material basically for fish stick-portion production or as an adjunct for other products.

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## Materials and Methods

Skinless fillets were produced by hand filleting 1-2 day old whiting obtained from a local processing plant July 1975. The fillets were formed in a plate freezer into 5.3-pound blocks measuring 6 x 10 x 2⅜ inches and packaged in the conventional dimpled waxedboard carton material.

Minced whiting was prepared by passing scaled, washed, headed and gutted fish with black belly lining removed through a Bibun meat-bone separator equipped with a drum with holes of 0.2 inch (5 mm) diameter. Minced blocks were formed in the same manner as described for fillet blocks.

The blocks were stored at various subfreezing temperatures which included 20°F, 5°F, −5°F, and −22°F and were tested periodically for eating quality, thiobarbituric acid (TBA) number (Yu and Sinnhuber, 1957; Sinnhuber 1958), dimethylamine (DMA) and trimethylamine (TMA) nitrogen content (Castell et al., 1974), and extractable protein nitrogen (EPN) content (Ravesi and Anderson, 1969).

The organoleptic evaluation was conducted by an experienced 12-member taste panel on oven-reconstituted, frozen, blanched, breaded fish sticks prepared from the

[1]Anonymous. 1978. Summary of stock assessments. Lab. ref. 78-40, 29 Aug. 1978. Resour. Assess. Div., NMFS, NEFC, Woods Hole Lab., Woods Hole, Mass.

[2]Mention of a commercial company or product does not constitute an endorsement by the National Marine Fisheries Service, NOAA.

[3]Combs, Earl R., Inc. 1977. Venture analysis and feasibility study relating to whiting and Atlantic mackerel. Contract Report No. 3-7-073-35121, 111 p. Fish. Dev. Div., NMFS, NOAA, P.O. Box 1109, Gloucester, MA 01930.

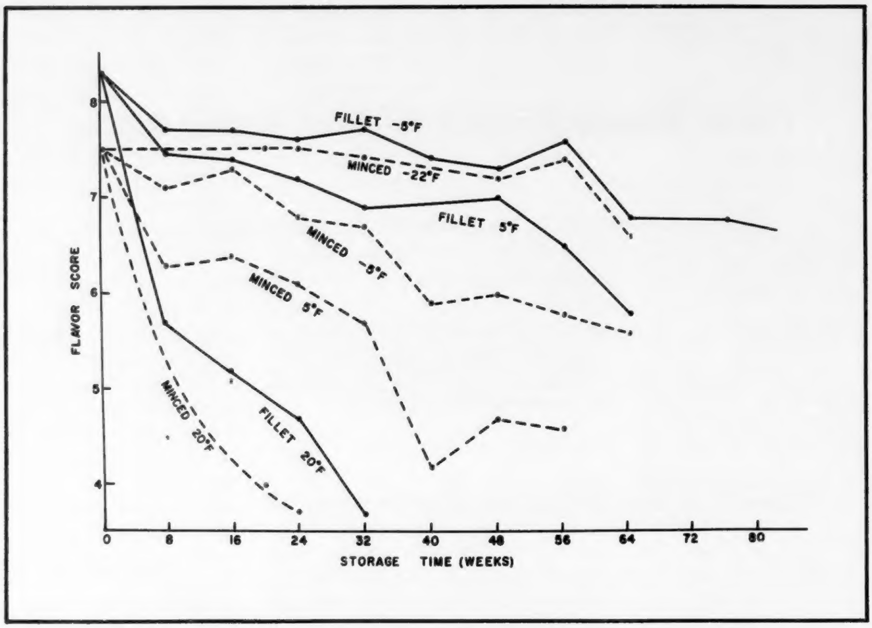


Figure 1.—Effect of storage temperature on flavor score of minced or fillet whiting blocks.

stored blocks. Samples were scored for flavor and texture on a 9 point scale in which numerical values were assigned to the rating categories as follows: 9–excellent, 8–very good, 7–good, 6–fair, 5–borderline, 4–slightly poor, 3–poor, 2–very poor, 1–inedible. A score below 6 was regarded as the index of unsuitability for marketing.

## Results and Discussion

Flavor scores and texture scores of the fillet or minced blocks have been graphed in Figures 1 and 2 as a function of storage time at various temperatures. Although not shown in the figures, the fillet blocks held at −5°F were still acceptable (score > 6) in flavor and texture after 2 years.

Two observations are readily apparent: 1) The beneficial effect of low storage temperature on stabilizing flavor and texture, and 2) the faster rate of quality deterioration in minced compared to fillet blocks.

The effect of temperature on the storage life of frozen seafoods is well documented (Slavin, 1960; Dyer and Dingle, 1961; Lane, 1964). Storage temperature is probably the single most important variable affecting the shelf life of frozen seafoods. The comparative instability of frozen minced hake blocks has been reported (Hiltz et al., 1976; Crawford et al., 1979). The gadoid species contain either an enzyme or some cofactor which, during frozen storage, degrades TMA oxide to DMA and formaldehyde with the subsequent development of tough texture and loss of water holding capacity caused by protein-formaldehyde interaction (Amano and Yamada, 1965, Yamada et al., 1969). Dark muscle has more of this enzyme activity than light muscle. The order of increasing enzymatic activity among gadoids was stated as: Haddock, cod, pollock, cusk, whiting, and red hake (Castell et al., 1971). In minced fish, this and other degradative reactions are accelerated (Babbitt et al., 1972; Hiltz et al., 1976) due to the partial disruptance of muscle and cellular integrity with subsequent release of enzymes, increased contact of light muscle with the more active dark muscle tissue, and increased opportunity for development of oxidative rancidity due to increased surface area.

The marketable shelf life of properly packaged minced or fillet whiting blocks at various temperatures was estimated from the curves shown in Figures 1 and 2, and the values are presented in Table 1. These results support the finding of Hiltz et al. (1976) that minced whiting deteriorated about twice as fast as the intact flesh. These workers also reported that there was a negligible deterioration in quality of minced or fillet whiting at −15°F for up to 6 months' storage. The results of

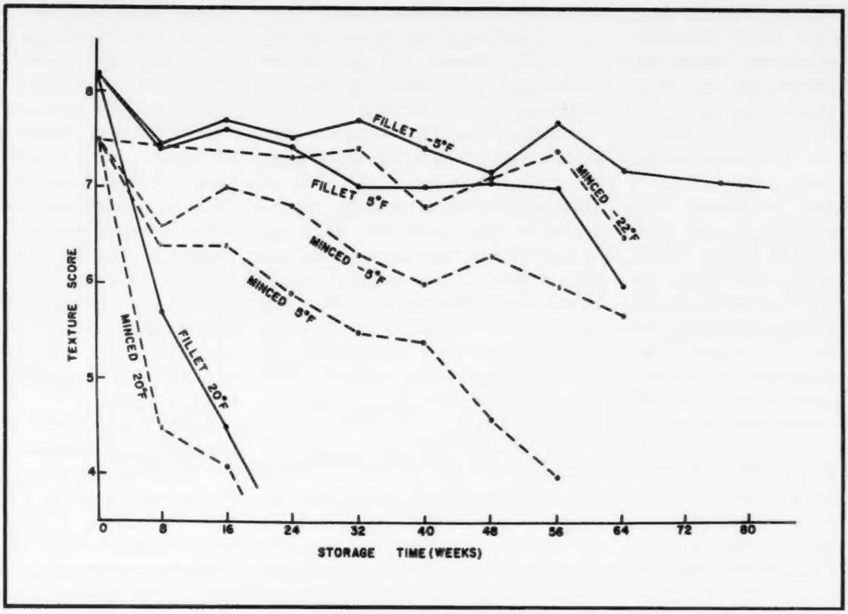


Figure 2.—Effect of storage temperature on texture score of minced or fillet whiting blocks.

the present study also corroborate this stability of whiting at very low temperatures.

A search of the scientific literature to determine what time-temperature relationships have been reported for frozen storage life of whiting revealed some variable data. A partial explanation for this variability is that shelf life estimation based on subjective sensory evaluation can be biased by regional preferences for what constitutes spoilage or nonacceptability. However, other subtle factors also exert an effect, for example, where and how the fish were caught, rate of freezing, packaging method, etc. (Slavin, 1963; Dyer and Peters, 1969). Whiting caught in summer were found to have a longer frozen storage life either in minced or fillet form compared with fish taken in winter (Hiltz et al., 1976).

**Table 1.—Estimated marketable shelf life (weeks) at various temperatures of minced or fillet whiting blocks.**

| Block form | Storage temp. (°F) | Shelf life (weeks) |
|---|---|---|
| Minced | 20 | 4 |
| Fillet | 20 | 7 |
| Minced | 5 | 22 |
| Fillet | 5 | 62 |
| Minced | −5 | 48 |
| Fillet | −5 | ≈104 |
| Minced | −22 | >64 |

The post-mortem age of whiting at the time of freezing has a significant effect on frozen shelf life. Peters et al. (1963) reported storage lives of 12 months at 0°F for whiting initially held 2 days on ice and only 6 months for fish which had been stored 4 days on ice. Storage in refrigerated seawater as compared with ice prior to freezing extended the shelf life of whiting by about 2-4 months at 0°F and about 1-2 weeks at 14°F (Peters et al., 1963; Hiltz et al., 1976).

Another variable which influences storage life determination is the particular criteria used for evaluating the quality loss. A summary of reported values for the frozen storage life of whiting in various product forms is presented in Table 2. In some instances, the storage life was based on EPN content, which is said to correlate with change in texture; and in other cases, it was based on a taste test on the steamed product. Estimating storage life by measuring a physical or chemical change which correlates with a single quality attribute is acceptable providing no other major changes are occurring. In the case of the whiting stored at 14°F, it was justified since it was shown that quality loss was principally due to textural toughening (Hiltz et al., 1976).

With regard to evaluating quality by tasting the fish steamed, it has been demonstrated that this particular cooking method allows for better discrimination among samples of frozen fish

which had undergone storage deterioration (Dyer et al., 1964). However, fried fish usually receives a higher rating in an organoleptic test than steamed fish (Licciardello et al., 1979); and on a 9 point scale, such as was employed in this investigation, fried whiting was rated one point higher in flavor compared with steamed whiting (Anderson and Mendelsohn, 1971). In the present study, the fish was tasted as fried sticks because it was anticipated that this would be the major product prepared from the blocks. Therefore, it is expected that the shelf life predicted for whiting from this investigation would be longer than that reported for fish tasted after steaming.

The original intent of this study had been to determine the frozen storage life of whiting blocks as handled under commercial conditions, that is packaged in the conventional dimpled waxedboard carton. This is a poor packaging material for frozen fish since it offers no barrier to oxygen and moisture vapor transmission; and as a consequence, the stored blocks in this study showed areas of surface dehydration within 2-3 months, which was sooner than anticipated.

From an industry position, this condition seriously reduces the utility of these blocks since the desiccated portion has to be trimmed off. This alters the dimension of the blocks with the result that the yield in raw fish sticks or portions per block is diminished. To rectify this problem, secondary processors are now specifying that frozen fish blocks be enclosed in polyethylene bags in addition to the normal packaging. In the present study, the surface dehydrated layer where present was removed prior to sampling.

Although the TBA numbers fluctuated from 1.0 to 2.5 during storage, the values were never indicative of rancidity. A similar variability was reported by other researchers, and it was speculated that this was caused by varying amounts of lipid-rich dark muscle in the sample (Hiltz et al., 1976). The tail muscle of whiting is known to be richer in lipid (dark muscle) than anterior sections. TBA numbers were slightly higher for minced compared with fillet blocks.

It should be pointed out that although a change in flavor did take place during storage, the typical linseed oil-like flavor of rancid fish oil was not detected. Oxidative rancidity as measured by the TBA test in minced whiting blocks (and probably skinless fillet blocks) occurs principally at the surface of the block, and this phenomenon can be suppressed with the proper packaging material (Licciardello et al., 1977). It is probably that in the present study, the process of trimming the outer dehydrated layer may also have removed any oxidized tissue.

Filleting whiting removes some of the fat which is concentrated beneath the skin and in a band of dark muscle along the lateral line. This treatment probably helps to reduce the problem of oxidative rancidity. With skin-on whiting fillets, however, quality loss during frozen storage at −8°F was reported to be due to rancidity development rather than textural change (Anderson and Mendelsohn, 1971).

In Figure 3, dimethylamine nitrogen content has been plotted as a function of storage time at various temperatures. The more rapid accumulation of DMA in minced flesh compared with fillets is readily apparent. It has been suggested that the concentration of DMA in frozen gadoid species could be used as a measure of frozen storage deterioration since it was found to correlate with the development of toughening (Castell et al., 1970; Tokunaga, 1974).

In the present study, linear regression analysis performed on DMA content as a function of texture score for blocks held at 20°F, 5°F, and −5°F gave correlation coefficients ranging from −0.88 to −0.99 for minced and −0.65 to −0.99 for fillet blocks. This high degree of correlation does indicate a strong association between formation of DMA (and formaldehyde) and deterioration of texture in whiting during frozen storage. From the regression lines, the value of DMA corresponding to the threshold texture score for unacceptability was estimated to range from 4 to 8 mg N/100 g. Hiltz et al. (1976) reported that at the point of complete inextractability of the myofibrillar proteins, which was their criterion for textural unacceptability in frozen whiting samples, the DMA level did not exceed 6 mg N/100 g.

It would be tempting on the basis of these two independent results to propose a DMA-N content of 6 mg/100 g as a biochemical index of textural unacceptability in frozen whiting. However, in more recent studies at this laboratory with whiting, higher DMA levels occurred at the time frozen minced or fillet samples were judged unacceptable in texture. The DMA index level of spoilage for frozen whiting was found to differ for summer-caught and winter-caught fish, and it was suggested that the DMA producing ability of whiting muscle may vary with season or possibly with fishing grounds (Hiltz et al., 1976).

In view of these variable results, it is

**Table 2.—Summary of reported values for frozen storage life of whiting.**

| Product form | Storage temp. (°F) | Method of evaluation | Storage life | Reference |
|---|---|---|---|---|
| Fillet | 14 | Chem. test (EPN) | 7-8 wk | Hiltz et al., 1976 |
| Minced (fillets) | 14 | Chem. test (EPN) | 4 wk | Hiltz et al., 1976 |
| Minced (H&G) | 14 | Chem. test (EPN) | 3 wk | Hiltz et al., 1976 |
| — | 0 | Not known | 5-9 mo | Slavin, 1963 |
| H&G | 0 | Taste (steamed) | 12 mo | Peters et al., 1963 |
| H&G or round | 0 | Not known | 8-10 mo | Lane, 1964 |
| Fillet (skin-on) | −8 | Taste (steamed) | ≥9 mo | Anderson and Mendelsohn 1971 |
| Round (glazed) | −8 | Taste (steamed) | ≥11 mo | Anderson and Mendelsohn 1971 |

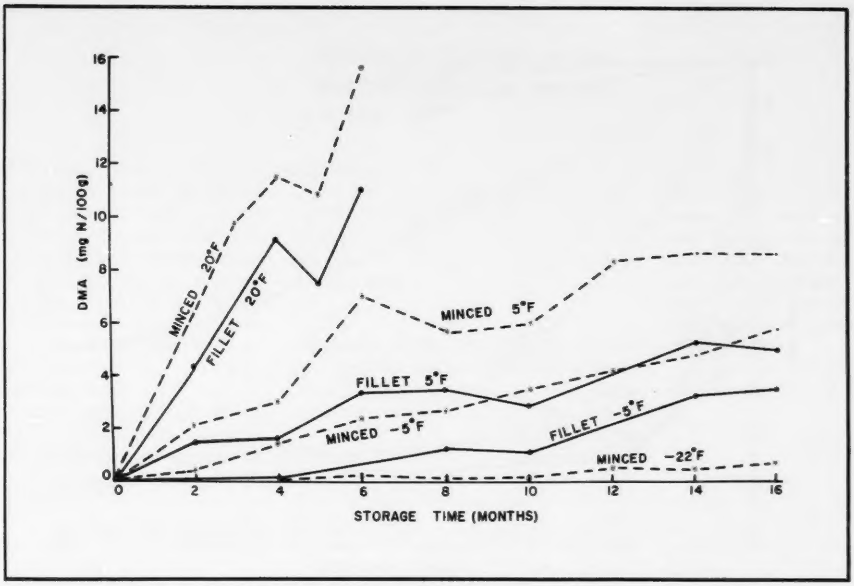


Figure 3.—Dimethylamine-N content of minced or fillet whiting during storage at various temperatures.

concluded that the DMA content of frozen whiting is a useful parameter for monitoring textural change in a controlled study but is not reliable for assessing textural quality in frozen whiting of unknown history.

The TMA content did not change significantly during frozen storage as would be expected since its development is contingent upon bacterial action. Values varied from about 0.2 to 1.2 mg N/100 g, which was indicative of very good initial quality fish.

The percent extractable protein nitrogen is plotted as a function of storage time at the different temperatures in Figure 4. The decrease in EPN was accelerated by mincing or by storage at the higher temperatures. Although the graphs clearly show that a loss in protein solubility that was commensurate with temperature occurred, the EPN content could not be used to predict textural storage life since textural unacceptability (determined organoleptically) occurred after the EPN curves had bottomed out. The EPN value represents the combined soluble sarcoplasmic and myofibrillar proteins. The value of EPN at the plateau represents the content of sarcoplasmic proteins, which are relatively resistant to freeze denaturation; however, it is the denaturation of the myofibrillar proteins that is associated with textural deterioration of frozen fish (Dyer, 1951).

Hiltz et al. (1976) concluded that the deterioration in quality of frozen whiting was due principally to its susceptibility to form DMA and formaldehyde, resulting in protein insolubilization. The results of the present study would support this conclusion. At present, the only known deterrent to this adverse reaction is low temperature storage, although the use of heat to inactivate the causative enzyme may have some application (Lall et al., 1975). Nevertheless, in assessing the relative stability of whiting with other gadoids, it was considered that the storage life at 14°F of whiting fillets was comparable with that of cusk or Atlantic pollock, less than cod, but greater than red hake (Hiltz et al., 1976).

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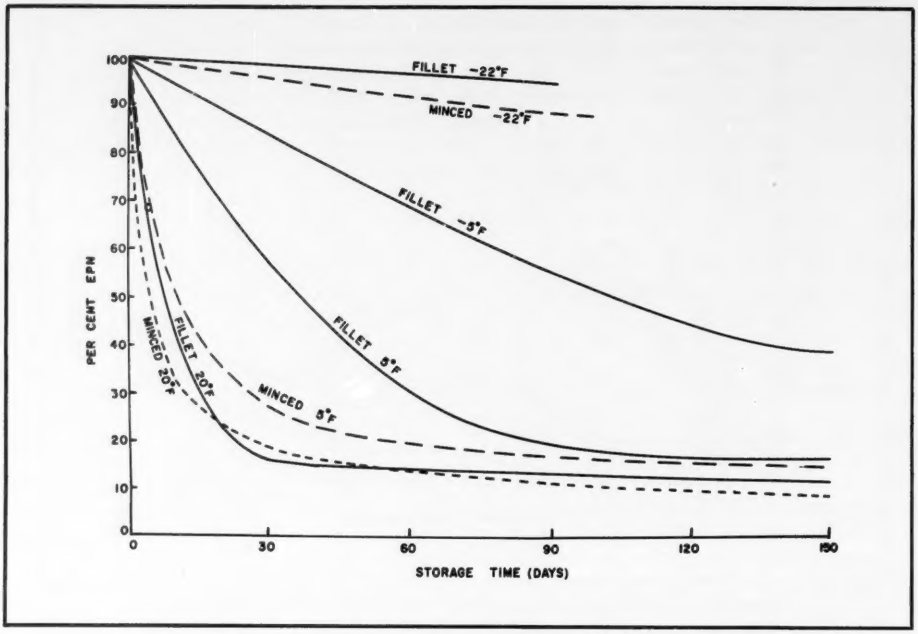


Figure 4.—Percent extractable protein nitrogen content of minced or fillet whiting during storage at various temperatures.

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# Editorial Guidelines for *Marine Fisheries Review*

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Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

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Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

### Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

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In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

### Tables and Footnotes

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Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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